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Optimal use of the hydro resources in Albania

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Master of Science in Energy and Environment
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Problem Description

Since fall 2007 Statkraft has had an engagement in Albania, a country which is totally dependent on hydro power. More than 90% of the electricity comes from hydro power, especially the Drin river in North Albania (Black Drin). The main objective with this study is to analyze the utilization of the hydro resources in Albania and to look at potential improvements in the short term (the next few years) and the long term (after Albania joins the regional market).

The study includes the following:

A. Describe the relevant hydro power projects in Albania under the present and future market conditions. Problems regarding rationing should also be analyzed.
B. Collect data and build a model in the EOPS model. The model shall include all relevant constraints of the present market conditions to get a reliable result. This includes the hydro power system, additional production, demand and supply and import and export.
C. Run simulations with the EOPS model and compare the results with historical data from the existing power plants. Analyze and explain the deviations.
D. Run simulations under a future scenario with a deregulated regional market . Analyze the changes in the supply situation in Albania and the utilization of the hydro power.

Assignment given: 02. February 2009
Supervisor: Gerard Doorman, ELKRAFT

Preface

This Master thesis finalizes my Master's degree at the Department of Electrical Power Engineering at the Norwegian University of Science and Technology (NTNU). The thesis has been written in cooperation with the South East Europe department at Statkraft.

First I want to thank Statkraft for letting me work with this interesting topic and for giving me the opportunity to spend five weeks in their office in Tirana. My supervisors at Statkraft, Bredo Erichsen and Snorre Mossing, deserve a great thankfulness for providing me with helpful information and encouragement handling this challenging topic.

I am also grateful to my supervisor prof. Gerard Doorman for helpful feedback and interesting discussions.

Final I want to thank my wonderful boyfriend, Henning Wahlquist, for his encouragement through the whole process.

Oslo, 28 June 2009

Heidi Theresa Ose

Summary

This Master thesis analyzes the optimal use of the hydro resources in Albania.

Albania is a country totally dependent on hydro power. More than 90% of the electricity today comes from hydro power, mainly from the Drin river system. There are three hydro power plants located in the Drin river system: Fierze (500 MW), Koman (600 MW) and Vau Dejes (250 MW). Only one third of Albania's hydro power potential is today exploited, and Albania is a net importer of energy.

The main objective with this study is to analyze the utilization of the hydro resources in Albania and look at potential improvements in the short term (next years) and the long term (after Albania joins the regional market).

Two scenarios were worked out. The first scenario focuses on the present market situation in Albania. Investigations are done through simulations with the EOPS model. The results were analyzed and compared with historical data to discover potential upgrades of the utilization of water in Fierze, Koman and Vau Dejes. In the simulations the production in Drin river system is increased with 1.3 TWh in an average year. Fierze power plant has the highest potential with 25% more production in the simulation than what is shown through historical data.

Under the process towards a liberalized market, the optimizing problem regarding the production planning will change. Today the main task is cost minimization given an expected demand. In a free market it will be profit maximizing given a price expectation. A second scenario dealing with the potential market situation in Albania in 2020 was worked out. In addition to the new market situation four new power plants were included in the EOPS model.

With new plants in the Drin and a functioning market it is possible to achieve 1 TWh more production during an average year compared with the simulation for the present market situation in Albania.

If the implementation of the market, new power plants and transmission lines are accomplished, the supply situation in Albania will improve substantially through more secure power delivery. However a participation in a regional market forces the production company to plan each day like the participants in the Nordic market, both in the long and short the term, to be able to exploit the technical and financial opportunities and develop their country.

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1 Introduction

Since fall 2007 Statkraft has had an engagement in Albania, a country totally dependent on hydro power. More than 90% of the electricity today comes from hydro power, and mainly the Drin river system. There are three hydro power plants located in the Drin river system: Fierze (500 MW), Koman (600 MW) and Vau Dejes (250 MW). Only one third of Albania's hydro power potential is today exploited, and Albania is a net importer of energy.

The power sector in Albania is undergoing a privatization and deregulation process. Albania wants to reform its power sector to fulfill its commitments in the Athens memorandum leading to the establishment of a South East Europe regional energy market, develop a system which is in accordance with European Union's Electricity Directive.

The main objective with this study is to analyze the utilization of the hydro resources in Albania and look at potential improvements in the short term (next years) and the long term (after Albania joins the regional market).

This report is divided into three parts. Part 1 presents theory of the production planning in the Nordic market, with focus on how Statkraft do their planning. The EOPS model which will be used to simulations in this study is explained. Further, theory about Albania in general and the present markets conditions in Albania are studied.

Part 2 looks at the situation in the Drin river system and the three plants that are being analyzed in this study. Historical production will be analyzed, before the Drin river system with its power plants will be simulated given the present market situation. The simulation results will be compared with historical data and the possible differences analyzed to find improvement potential.

In the last part, part 3, a future 2020 scenario will be studied. This scenario assumes an open regional market, which functions with the same principals as the Nordic market. New simulations with the developed market, new transmission lines and new operating plants in Drin will be made.

Final analyzes will be made by comparing the results from the future scenario with historical data and simulation of the present situation to discuss the optimal way to utilize water in 2020. In the end the possible future supply situation in Albania will be presented.

PART 1: THEORY

In part 1, theory that will be needed later in this study is presented.

2 Hydro power scheduling

One of the subjects for this study is to analyze the potential for improved utilization of the existing plants in the Drin river system under the present market situation in Albania. To do this software for long term optimization, the EOPS model, will be used. To understand the theory behind the model, the Nordic market will be briefly explained. Thereafter the model for price forecasting EMPS will be look at. The main focus is on the generation planning model, EOPS, which will be used later in this study to simulate the Albanian river system, the Drin.

2.1 The market

The Nordic power exchange market is a liberalized market that includes Denmark, Norway, Sweden, and Finland. When the power market is liberalized, power will be a common commodity, on par with for instance petrol or oatmeal (Houmøller, 2006).

The major benefit of the Nordic power market derives from the opportunity it provides for the participant countries to assist each other when additional electricity supplies are required. If one country is unable to satisfy demand from its output, it can import the necessary power from a neighbor. Since the generating modes differ and are distributed differently in the various countries, the need for additional power will vary from country to country and at different times. A common Nordic resource pool therefore helps to optimize the use of available power and reduce local deficits (Nord Pool).

The Nordic power exchange (Nord Pool) operates a day ahead spot market, financial derivates market, emission market and clearing services. In this study only the day ahead spot market will be presented.

2.1.1 Nord Pool Spot market

At the spot market participants trade power contracts for physical delivery for the next day, hence the market is referred to as a day-ahead market. The physical market's primary function is to establish a balance between supply of and demand for electricity on the following day.

Every participant fives their bids and offers to Nord Pool before 12 am every day. At Nord Pool spot, the bids and the offers for each hour the following day are put together to one aggregated supply curve and one aggregated demand curve. The so-called system price can be read at the point where the two curves intersect one another. From figure 1 the overall demand (red curve), overall supply (green curve) and the system price can be seen.

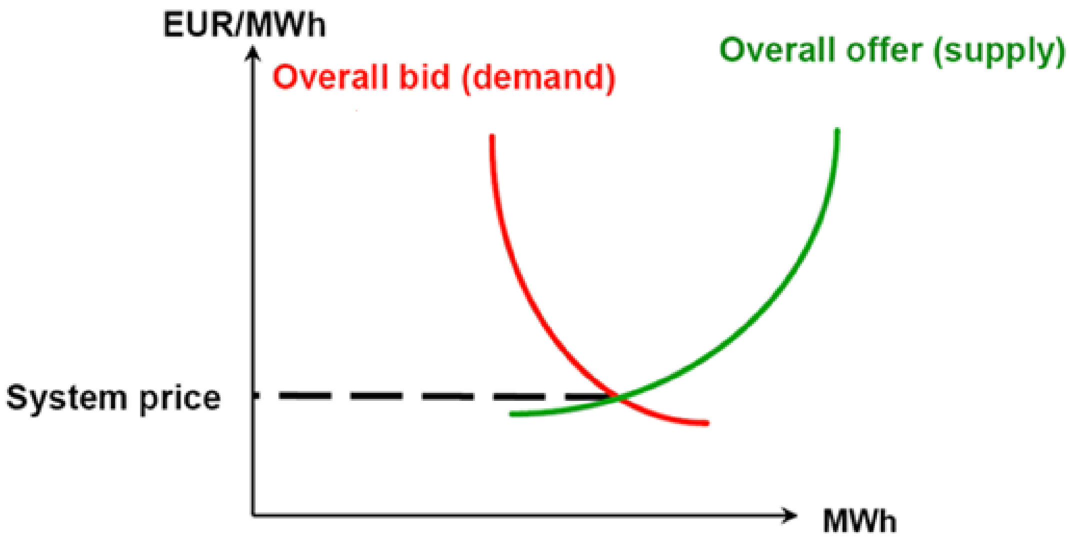

Figure 1 Nord Pool spot: Bids and offers are set together to find the system price (Houmøller, 2006).

The physical market price on Nord Pool is set in the same way as on other commodity exchanges – through a market pricing. The difference compared with other markets is that electricity is a commodity which must be generated and consumed simultaneously (Nord Pool).

When the system price is decided the power balances in each area is considered. The area prices are adjusted in order to keep the transfer within the capacity limits. The preliminary settlement is finished and the participants are notified by 2 pm. Now the participants can start to work out their final production schedule.

2.2 Planning for the next day in the Nordic Market

Statkraft is a participant in the Nordic power exchange market. Under a market regime the planning criteria implies in principle maximization of profits.

For a producer in the Nordic power market, the basis problems to be solved in the scheduling process are (Haugstad, Flatabø, Fosso, & Mo):

1) Find out how much power to offer the market coordinator as a function of price, for each hour in the next 24 hours.
2) Once the market price is fixed (every hour the next 24 hours), the optimal schedule has to be recalculated.

As seen from 1) the producers usually need a model for the market system since the price forecast is an important input in the scheduling. Prices depend on inflow as well as fuel costs, demand and power system expansion. For the producers, reliable price forecasts are essential for successful generation scheduling, risk management and investment planning.

The model that Statkraft uses for this task is the EMPS model. This model is widely used in the Nordic countries for the purpose of price forecasting (Haugstad, Flatabø, Fosso, & Mo). There are also other alternative approaches available for forecasting the future market price, for example statistical models based on market expectations, but these will not be discussed in this study.

2.2.1 EMPS model – market modeling

EMPS (EFI's Multiarea Power Market Simulator) was developed by Sintef Energy Research (former EFI) in the 1970s, as a simulation tool for hydrothermal power systems with a substantial fraction of hydropower (Doorman, 2007).
The model aims at optimal use of hydro resources, in relation to uncertain future inflows, thermal generation, power demand and spot type transactions within or between areas (SINTEF, EMPS, 2008).

The decision process is divided into two parts: a strategy part and a simulation part.

The strategy part calculates the expected value of the water, the water value, as function of stored water and time in the aggregated model (SINTEF, Brukermanual Vansimtap, 2009). Once the water values are calculated, a detailed simulation is performed, with all relevant details being modeled. Under simulation, an advanced, rule based drawdown strategy is used to decide a best possible allocation of water between individual reservoirs (SINTEF, EOPS, 2008) . After the allocation of the water the optimal production is calculated.

When the simulation is done, Statkraft will get a price forecast as shown in figure 2. The forecast is given in different percentile (0,25,50,75,100) for the next three years. Statkraft also closely supervises other elements that can influence the price, but are not represented in the EMPS price forecast. They are factors like unpredictable psychological effects and varying prices in coal, gas, oil and CO2. These factors can often lead to adjustments in the forecast.

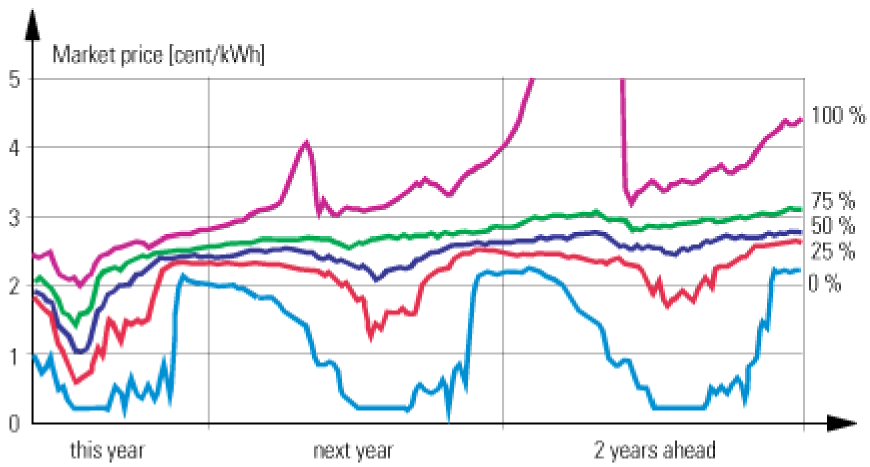

Figure 2 Example of price forecast from the EMPS model (SINTEF, EMPS, 2008)

Once the producer has its price forecast they use it as an input in scheduling models, and when the schedule is done they place their bids to Nord Pool.

The EMPS model is also used for a number of other purposes than price forecasting, but this will not be discussed in this study.

2.2.2 Generation planning

When Nord Pool has received all the bids, they calculate the market price as explained in the market chapter. When the producers get the fixed market price they usually need to reschedule since the market price may vary from their own price forecast.

The generation planning in Statkraft involves a lot of models, high competence and a flexible approach. There are many different departments in Statkraft which need to cooperate well to achieve a good result.

One of the models used in generation planning is the EOPS model. This model will be used later in this study to simulate the generation planning in Albania.

2.3 EOPS

The EOPS (One-area Power-market Simulator) model was like its "big sister", EMPS, developed by Sintef in the 1970's**.** EOPS is a model especially suited for long term scheduling and expansion planning in hydropower dominated areas.

The EOPS model is a stochastic model for long to midterm optimal scheduling and simulation of a general hydro-thermal electrical system, although the main focus is clearly on hydropower. It is mainly used for local scheduling, since it is a single area model with a single bus bar and no grid.

Within the simulated area there should be no major transmission constraints and the area should have some degree of homogenous hydrological characteristic (SINTEF, EOPS, 2008). In the EOPS model the price is usually externally given, and is treated as a stochastic variable.

2.3.1 The nature of the model

Given a hydropower system, the EOPS model seeks to find an optimal disposal of resources and contracts.

One of the most important simplifications done by the model is aggregating every HPP in a river system, which may consist of several power plants and reservoirs, into one single plant with one reservoir in the strategy phase. This is called a standard hydro power module and is showed in figure 3.

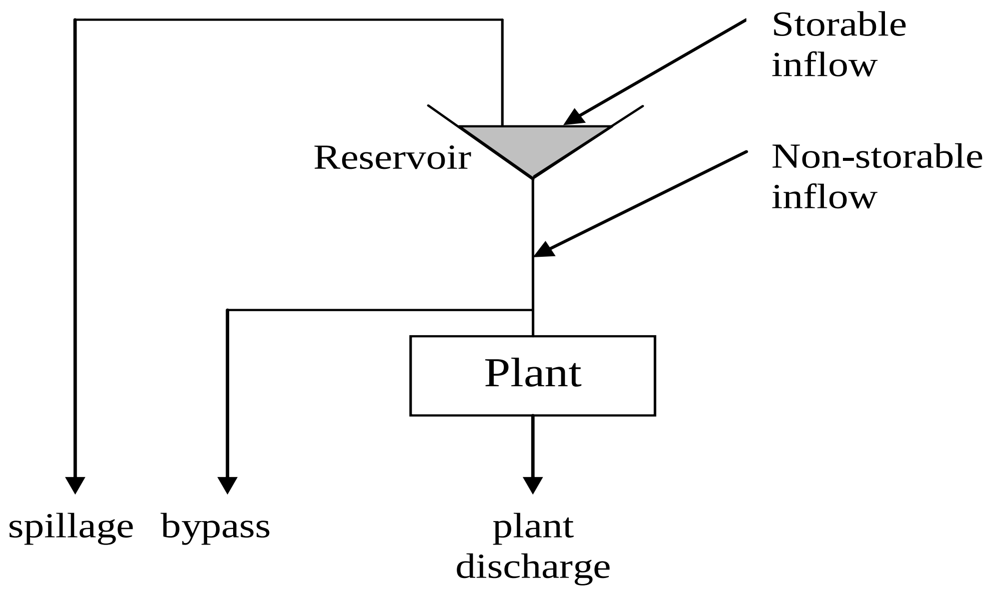

Figure 3 Standard hydropower module (Doorman, 2007)

The standard module includes (Haugstad, Flatabø, Fosso, & Mo):

- A reservoir, defined by its storage capacity and a relationship between volume and elevation.
- Inflow, both storable and non-storable (i.e. forced generation)
- A plant, defined by its discharge capacity and a piecewise linear relationship between total plant discharge and generation.
- Separate destinations for plant discharge, bypass discharge and reservoir spillage.
- Variable constraints on reservoir contents and water flow (plant and bypass discharge)
- Pumping capability, either reversible turbines or dedicated pumping turbines.

All the standard modules in the subsystem are then joined in one aggregated model, and the hydro power system is thus modeled as one resultant module with its reservoir, inflow, restrictions and market obligations. The simplified one area model is presented in figure 4.

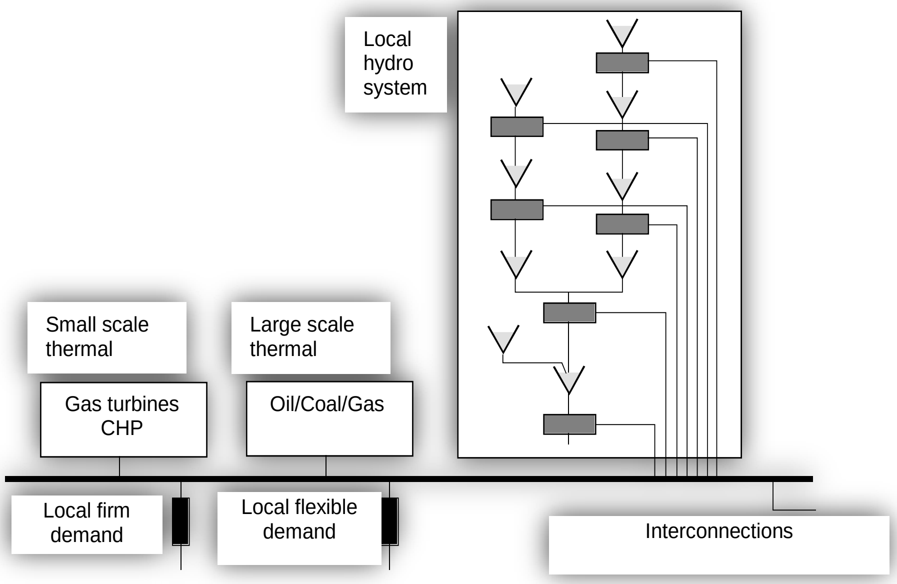

Figure 4 Aggregated model (Doorman, 2007)

The decision process is the same as explained for the EMPS model, with a strategy part and a simulation part.

Depending on the purpose of the simulation, two different approaches exist: simulation in series or in parallel.

This study seeks to find the optimal use of the hydro power resources in Albania through optimal production. For this purpose the simulation will be done in series. Today's situation doesn't have a strong impact it's what happens in the long run that matters. The series simulation implies that the initial reservoir volume of an inflow scenario is set equal to the final reservoir volume of the preceding inflow scenario, linking the years of inflow together.

3 Albania

The republic of Albania is situated in south east Europe at the western shore of the Balkan Peninsula. Albania is bordering on Greece to the south, FYR of Macedonia to the east, Montenegro to the northwest and Kosovo to the northeast. To the west it faces the Adriatic Sea and to the Southwest the Ionian Sea.

Albania covers an area of 28,748 square kilometers (Nenad, 2007).This is a small area approximately with the same size as Hedmark fylke in Norway.

The population is about 3,15 million with most of the people situated in the large cities (Sogreah, 2008). In table 1 the population of the main towns of Albania is shown. The largest city is Tirana which also is the capital. For the location of the different cities look at the map in appendix A.

City	Population
Tirana	376 642
Elbasan	123 270
Durrës	116 275
Vlorë	104 118
Korçë	84 593
Fier	64 537
Berat	62 970
Lushnjë	47 438
Gjirokastër	33 973
Kavajë	33 570

Table 1 Population in the biggest cities in Albania (Sogreah, 2008)

The Albanians and their country have a turbulent history and the politics and the economy have been a bit unstable. After a stay in Albania it came clear how much the history and politics influence the people. Both in the way they think and react. Therefore summaries of these topics will be briefly gone through.

3.1 History

In 65 BC the Albanian area becomes part of the Roman Empire. Following the split of the Roman Empire in 395, the East Roman Empire establishes its control over the area. The East Roman rule is interrupted by the Goths, the Celts and the Huns. The Ottoman Empire rules Albania from 1385 until 1912. Ottoman rule was interrupted by the 1443-78 revolt, led by Albania's national hero, Gjergj Kastrioti Skenderbeg. In the early 20th century, the weakened Ottoman Empire is no longer able to suppress Albanian nationalism (Electionworld).

In 1912 Albania secedes from the Ottoman Empire and becomes independent. In 1944 the communist party succeeds in liberating the country. This leads in 1946 to a communist dictatorship under the Partia e Punës ë Shqipërisë (Labour Party of Albania, PPS) of Enver Hoxha (Electionworld). For 40 years thereafter, Albania's leader Enver Hoxha developed and ran a strict communist state.

Albania, then as now one of Europe's smallest and poorest countries, which first traded with the Soviet Union and Central European countries. But in 1961, Albania switched allegiance to China, as a result of Hoxhas severed relations with the Soviets on ideological grounds. The allegiance with China lasted until 1978. Hoxha finally died in April 1985 and was replaced by Ramiz Alia (Platts).

In 1990 the dictatorship collapses and the country is renamed Republic of Albania in 1991.

Now the country that once was known as a shadowy communist prison state is emerging from a difficult transition period. The transition has proven challenging as successive governments have tried to deal with high unemployment, widespread corruption, a ruined physical infrastructure, powerful organized crime networks, and combative political opponents.

Albania has made progress in its democratic development since first holding multiparty elections in 1991, but deficiencies remain. International observers judged elections to be largely free and fair since the restoration of political stability following the collapse of pyramid schemes in 1997. However, there have been claims of electoral fraud in every one of Albania's post-communist elections.

In the 2005 general elections, the Democratic Party and its allies won a decisive victory on pledges of reducing crime and corruption, promoting economic growth, and decreasing the size of government. The election, and particularly the orderly transition of power, was considered an important step forward. Albania joined NATO in April 2009 and is a potential candidate for EU accession. Although Albania's economy continues to grow, the country is still one of the poorest in Europe, hampered by a large informal economy and an inadequate energy and transportation infrastructure (The World Factbook).

3.2 Politics and Economy

Albania began its post-communist transition with many of the awkward features of centrally-planned economies including over-investment in heavy industry, collective agricultural policies, few consumer goods, obsolete infrastructure, and massive unemployment. In the early 1990s, Albania's leaders began privatization activities and loosened restrictions on trade and foreign investment and these initiatives were rewarded with positive growth. The Albanian economy remained in fragile condition and economic conditions again deteriorated after 1996, accompanied by periods of social unrest and political instability (Platts).

As part of the continuing transition to a market economy, the government is planning to continue its privatization initiatives and hopes to divest state-owned companies in the industrial and service sectors including oil, electric power, telecommunications, transport infrastructure, and water resources. A "Strategic Sectors Privatization Strategy" was developed to coordinate the various privatization programs and establish the main objectives and techniques needed to move forward (Platts).

Today Albanian republic is a parliamentary democracy established under a constitution renewed in 1998. Elections are held every four years. The last election was in 2005, where Sali Barisha was elected prime minister. There will be a new election in 2009.

In spite of the government's generally successful efforts to maintain macroeconomic stability, Albania has some significant financial challenges. One is a large current account deficit attributable to a steady increase in imports. In 2007, this was exacerbated by widespread electricity shortages attributed to drought conditions and leading to a quadrupling of power purchases. The adverse financial impact of these expenditures is somewhat offset by a large and continuing flow of remittances from Albanians working abroad. This amounts to almost 15% of GDP (Platts).

Goals and objectives in the energy sector are to fulfill the EU directives and the Athens MOU II[1]. Albania aspires to join the EU, and this is described as "an important national goal" in the power sector policy statement. Albania signed the Athens MOU in 2003 and have with that undertaken to cooperate in creating a regional market for electricity (REM) in south east Europe (Kamberi, 2005).

3.3 Geography of Albania

Albania is a country of hilly to mountainous relief with a higher topographic and climate variation than what is normal in other European countries. About 70% of the country is at an elevation higher than 300m asl. The average country altitude is 708,5m asl.

Topographically and morphologically, Albania is divided into four areas: the Albanian Alps, the Central Mountainous Region, the Southern Mountains Region and the Coastal Lowland. Over a third of the territory of Albania – about 10,000 square kilometers is forested and the country is very rich in flora.

The extensive hydrographic system of Albania comprises 11 main rivers with 152 tributaries and large streams.

[1] The Athens MOU is a contract between the countries in South East Europe and EU. The contract includes the development of a regional market that eventually is going to be integrated into the European Union's internal electricity market.

Figure 5 Topographic map of Albania (Wikipedia)

Drin River is the longest Albanian river, of which 285km lies in Albania (Black Drin, and then Drin downstream of the confluence with White Drin).

The hydrographic system also includes three large lakes: Shkoder, Ohrid,and Prespa. The country is also rich in groundwater, with 200 water sources estimated, each of about 200 liters per second (Sogreah, 2008).

The Drin river and the lakes mentioned are shown in figure 5.

3.4 Climate in Albania

With its coastline facing the Adriatic and Ionian seas, its highlands backed upon the elevated Balkan landmass and the entire country lying at latitude subject to a variety of weather patterns during the winter and summer seasons, Albania has a high number of climatic regions for so small an area. The coastal lowlands have typically Mediterranean weather; the highlands have a Mediterranean continental climate. In both the lowlands and the interior, the weather varies markedly from north to south (Wikipedia).

There are two main factors that create the variability in the climate: altitude over sea level and distance from the sea (Eglantia). Generally the precipitation decrease from west to east. The highest values are found near the Mediterranean in west, the lowest in the mountains. Snowfall is normal in the mountains, less normal in the lower parts of the country (Erichsen).

3.5 Drin River

The Drin river system is the largest river in Albania. In the North it collects water from the Adriatic portion of the Kosovo watershed and Montenegro (White Drin) and in the south from the border region with FYR Macedonia (Black Drin with drains Prespa Lake and Ohrid Lake). This can be seen on the map on the next page. The water course length of the Drin River is 285 km in the Albanian territory with an average inflow of about 197 m^3/s and two main branches. The Drin River is the most constant river in Albania, fed by melting snow from the northern and eastern mountains and more frequent seasonal precipitation (Sogreah, 2008).

Other major rivers in Albania include the Devol and the Osum. Albania also borders on three large lakes: Lake Scutari in the north and Lake Ohrid and Lake Prespa along the Macedonian border (Sogreah, 2008).

Figure 6 Picture of Drin river

3.5.1 Climate and hydrology in Drin

Most of the Drin flows through a steep valley in the highland. The most important climate elements that must be taken into consideration in the area are precipitation coming as rain and snow.

Snow is a phenomenon present every year in the high areas, resulting in a melting period.

There is little precipitation in the eastern part of the Drin zone, while the central and western part of this zone is characterized by high precipitation values. The observed amounts vary from 910 mm in the east (Kukes) up to 2260 mm in the central part (Iballe). The highest amount of precipitation is recorded during the cold months (October-March), about 66 % of total. November -December are the wettest months, while the driest are July-August (Eglantia).

The different zones are showed in different colors in the map below. The red zone represents the Drin area.

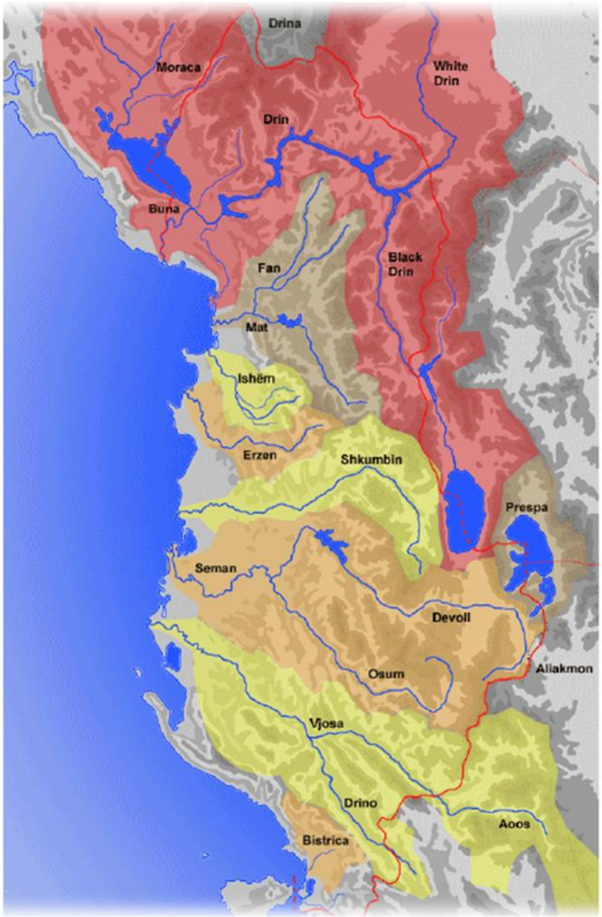

Figure 7 Map showing different hydrology zones in Albania (Sogreah, 2008)

Floods are common in Albania, resulting from rainfalls of high intensities. In the Drin zone the flood is usually located in Shkoder.

4 Electricity market

In Albania the ministry of Economy, Trade and Energy (METE) is in charge of the whole energy sector. METE represents the highest state authority responsible energy policy-making. Their mission is to promote a steady, sustainable economic development.

Today's electricity market regime is based on a Law on Power Sector which came into force on May 23th 2003, with the aim to restructure the Albanian power sector (ERE Government of Albania). The market is today undergoing changes in the privatization process following the Transitory Market Model (TMM) that was approved by the Albanian Council of ministers in 2004 (Atwood, 2007). The initial structure of the TMM is intended to be a transition phase that provides the flexibility for the Albanian market to evolve toward full compliance with the EU directives and the Regional Electricity Market (REM) by the Athens MOU II. In 2007 the Albanian government approved a new market model for the future Albanian electricity market, the Albanian Market Model (AMM) based on a decentralized bilateral contracts model. This model will be looked at more closely at in Part 3.

How far in the process toward implementation of the AMM the energy sector has aimed to come has been impossible to answer precisely. But the market actors roles today will anyways be presented.

4.1 Electricity Regulatory Authority (ERE)

ERE exercises the regulatory functions of the state in the power sector. ERE was officially established in 1996 and is an independent institution. ERE has the responsibility of regulating the performance of Market participants. Law on Power Sector provides a legal basis for the exercise of those responsibilities by ERE.

ERE's functions are as following (Austrian energy agency, 2005):

- Approval of rules and requirements for applications, granting, amending and withdrawing of licenses to companies carrying out generation, transmission, distribution, supply, export and import activities.
- Setting the wholesale and retail tariffs as well as terms and conditions of electricity service.
- Protection of interest of electricity consumers.
- Settling the disputes between the licensees and consumers and amongst the licensees themselves.
- Maintaining the balance between interests of the licensees, consumers, state and other participants in the power sector.
- Promotion of competition in power sector.
- Approval of market rules, grid code and other codes governing the licensees activities in the power sector.

4.2 Market actors

All the agreements between the market actors are regulated by ERE, including the bilateral agreements. A key goal during the transmission phase was to move from the old structure of KESH (vertically integrated utility without separate accounts) to a functionally, legally and financially separate generation, distribution and transmission entities (ERE Government of Albania). This has been successfully accomplished, even though KESH generation struggles with financials.

The transmission system operator, OST

OST is an independent state owned company that owns, maintains, operates and expands the transmission system. OST verifies, with information provided by the distribution company and other market participants, the annual, weekly and day ahead basis for supply to Tariff customers for energy and ancillary service (ERE, ERE Government of Albania).

OST will receive compensation for its services, including compensation for the ownership, maintenance and operation of the transmission service, from the market participants pursuant to tariffs approved by ERE (Austrian energy agency, 2005).

KESH generation, KESH gen

KESH gen is the only company supplying the country with energy. KESH gen sells ancillary services and electricity generated by existing hydro units at prices approved by ERE to the distribution company. KESH also sell additional imported electricity to meet the load of tariff customers to the distribution company.

KESH gen has been criticized because of successive power crises. In an effort to ease them, KESH has received government subsidies to ensure it has the necessary financing to import energy. (Koci, 2008). If KESH gen has excess generation available they may, with ERE approval, sell or “swap” that excess into the export market so long as the financial value of the export is fully transferred to the distribution company for the benefit of the tariff customers (Gana Gjini, 2009).

The distribution company, CEZ (formerly OSSH)

March this year the Government of Albania and CEZ (Hungary) Group signed a contract for the sale of 76% of the shares of the electricity distribution company of Albania (OSSH) (Novakova, 2009). The distribution company is now an independent, privately owned company.

The distribution company owns, maintains, expands and operates the distribution system throughout Albania. They are also responsible for buying energy, capacity and ancillary services for its tariff customers and for purchasing ancillary services on behalf of eligible customers (see below) (ERE, ERE Government of Albania).

The CEZ has to demonstrate to OST that it has procured sufficient supply to serve its load (Austrian energy agency, 2005).

Small Power Producers, SPP

Small Power Producers (small hydro and cogeneration of 5 MW or less) shall be licensed in the country to sell capacity and energy to the distribution company, to the export market, or to eligible customers at commercially agreed upon terms, or, if no agreement can be reached, on terms approved by the ERE that both facilitate development of such projects and provide consumer benefits (Austrian energy agency, 2005). SPP has today an installed capacity on 20 MW and an annual production on 100 GWh each year.

Independent Power Producers, IPP

IPPs (including Combined Heat and Power Plants ("CHPs") in excess of 5 MW may be developed and licensed and may sell capacity or energy to the export market or to eligible customers at market prices, or to the Distribution Company at a contract price approved by ERE. The ERE shall determine in issuing the license to which category or categories of customers the IPP may sell (Austrian energy agency, 2005).

Today IPPs are not on the market, but the market is getting ready to implement them as soon as they are constructed. When Statkraft complete their power plants in Albania, they will function as an IPP.

External Suppliers

External suppliers that are located outside the country may export power to KESH gen, the distribution company or the eligible costumers (ERE, ERE Government of Albania).

Tariff costumers

Tariff customers are customers that purchase electricity at regulated rates (from ERE) from the distribution company (ERE, ERE Government of Albania).

Eligible costumers

An eligible customer has the right to choose the electricity supplier (SPP, IPP, External supplier) for the electricity used for their own needs. They will enjoy the same rights to use the transmission and distribution systems after they decide to leave KESH gen as their supplier for electricity. It is today a high threshold (10GWh/year) to become eligible (Energy Comunity, 2007). There are today at least two big customers that have been granted by ERE the status of eligible (Albania-EU Efficiency center). The steel producer Kurum which is located in Elbasan is one of the eligible costumers.

4.3 Market structure

The relationships among, and the role of, market participants in the physical operation of the market are to be set forth in bilateral contracts between various participants. A schematic description is showed in figure below, followed by a more detailed explanation.

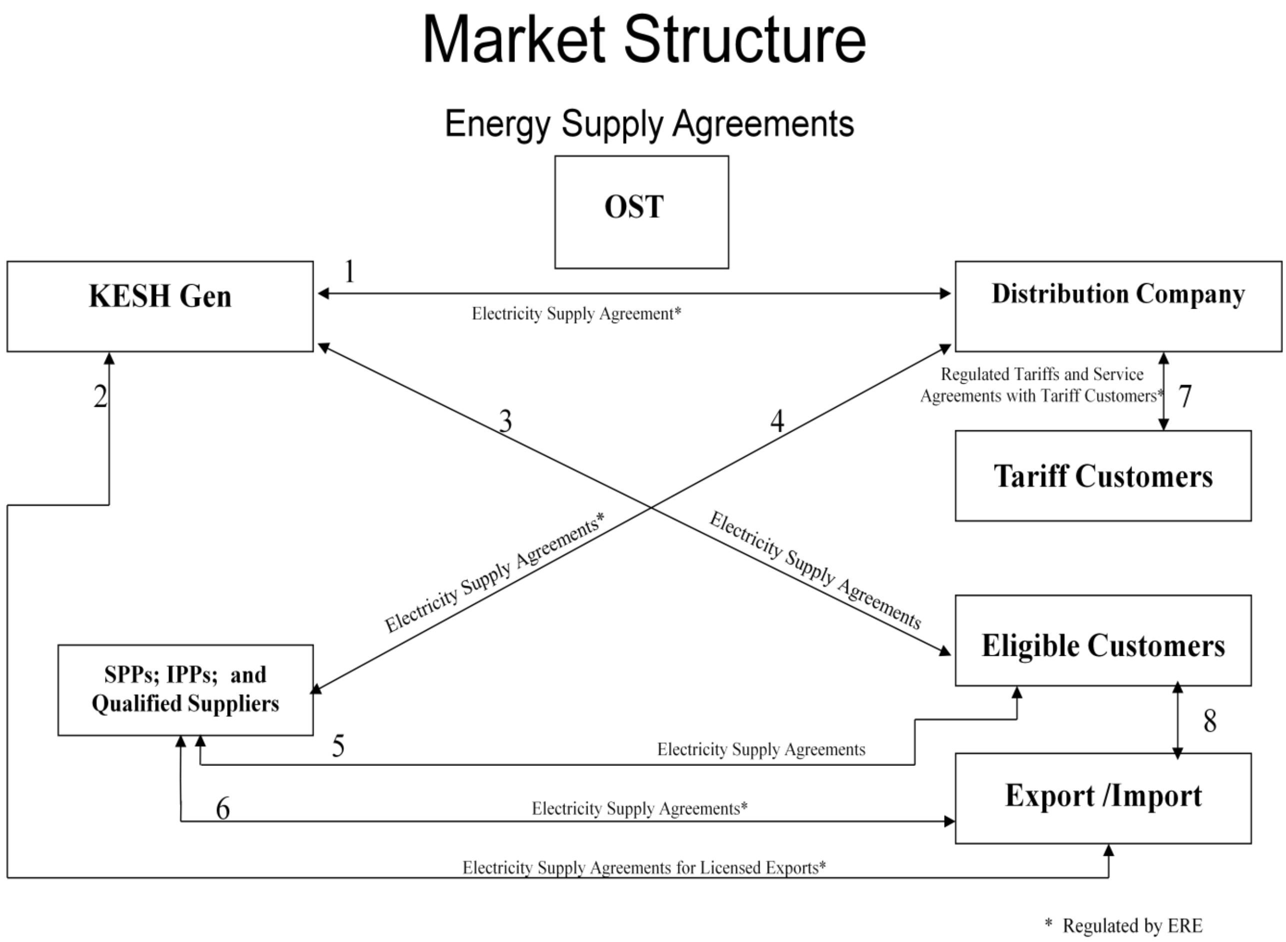

Figure 8 Market structure, the numbers in the figure is explained below

.

The different agreements between the market participants:

1) Between KESH gen and the distribution company: KESH gen sells ancillary services and produced electric power to the distribution company at tariffs approved by ERE (Austrian energy agency, 2005).
   They also sell additional imported electricity requested by the distribution company to meet the load of the tariff costumer (Austrian energy agency, 2005).

2) Between KESH gen and the export/import market: KESH gen must import energy to meet the electricity request by the distribution company.
   To manage to finance the imported energy, KESH gen gets subsidies from the Government.
   If KESH gen has excess generation available they may, with ERE approval sell or swap that excess into the export market (Austrian energy agency, 2005).

3) Since there are no other big producers in the market today, the eligible customers can only buy Albanian energy directly from KESH gen trough bilateral contracts.

4) 5) and 6) IPP (When they come) and SPP may be licensed by ERE to sell capacity or energy to the export market, eligible customers or the distribution company at tariffs set by ERE.

7) Between distribution company and tariff customers: The distribution company sells energy and services to their tariff customers at prices regulated by ERE.

8) Eligible customers should have the right to choose an external energy supplier.

4.4 Electricity tariffs

Electricity is the only energy commodity that does not have price liberalization status in Albania (Austrian energy agency, 2005).

As of today the electricity tariffs are totally regulated by ERE. The Tariffs for 2008 is showed in appendix B.

The tariffs are divided into three voltage levels: High (110 kV), Medium (6/10/20/35 kV) and Low. For the tariff costumers there are two different alternatives: Non households that have a fixed price and households which have stepwise price. For the households, the first step is consumption until 300 KWh at the price 7 lek/KWh and the second from 300 KWh at the price 12 lek/KWh. 100 lek correspond to 0,75 EUR or 6,5 NOK (ERE, Tariffs 2008).

4.5 Transmission system

The high voltage transmission system in Albania consists of 400,200 and 110 kV lines. Albania has three interconnection lines to neighboring countries, two 220 KV lines and one 400 kV line. The 220 kV lines goes from Fierze to Prizereni (Kosovo), and from Vau Dejes to Podgorica (Montenegro). The 400 kV line goes from Elbansan to Kardhja (Greece) (Sommerfeldt, 2009). This is shown in Figure 7, the green line is 220kV and the red line is 400kV. There is a fourth line in the south going from Bistrice to Igumenice (Greece) at 150 kV, but this line is normally out of operation.

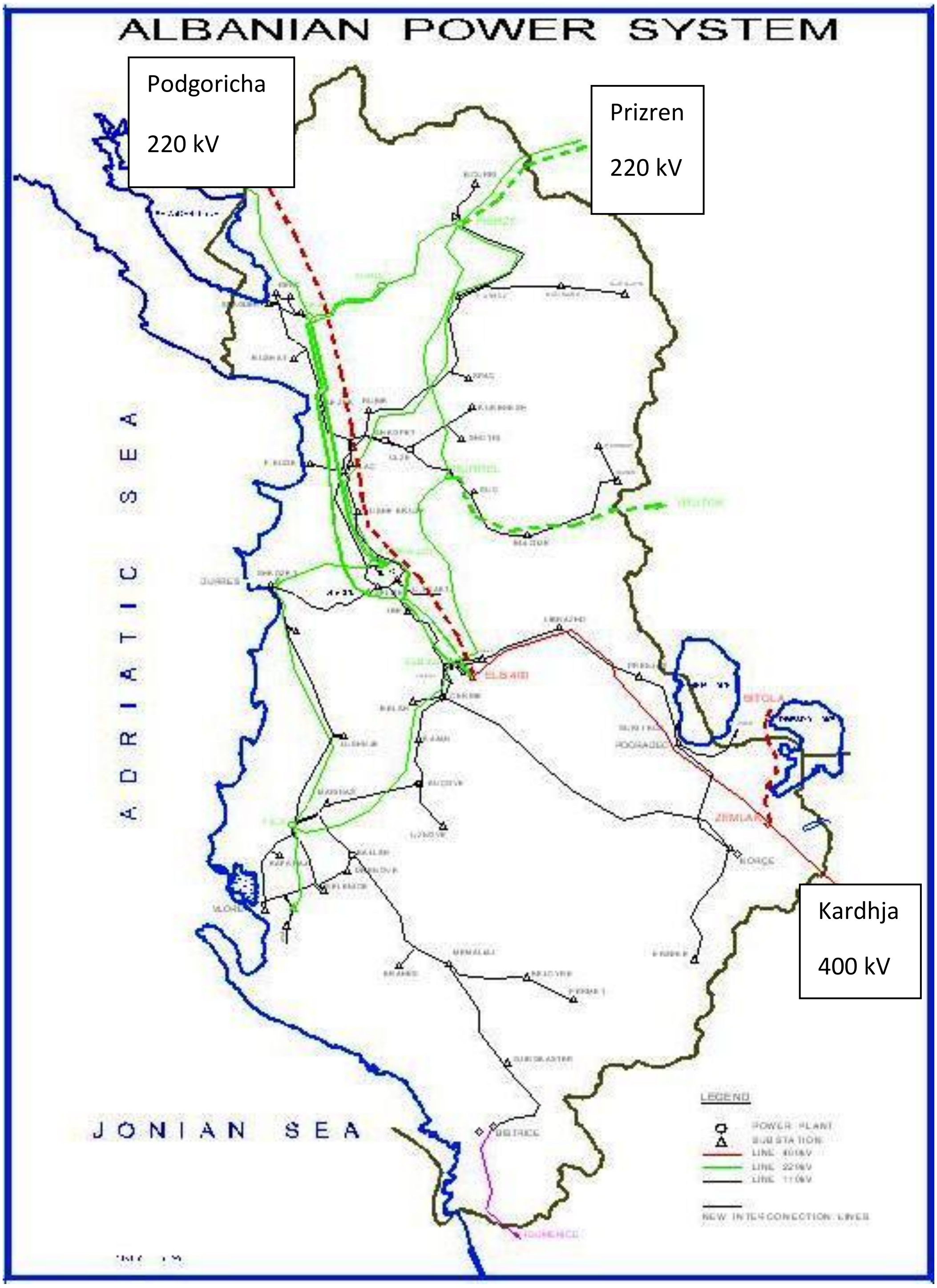

Figure 9 Albanian Power system

The majority of the power production is located in the north of Albania in the Drin river. While the main load centers are in the center and south (Tirana, Elbasan and Fier). The originally transmission and distribution system was not designed to service todays load centers, which became dominant following the shift from industrial to domestic demand (Nenad, 2007) . There has been little change in the networks after the change in flow patterns to alleviate bottlenecks.

The power transfer from north to south results in a voltage drop when there is high production in the Drin River Cascade. And the technical losses have risen to exceptionally high levels, even without considering non technical losses (Sommerfeldt, 2009).

5 Electric power overview

Albania is known for its large hydropower potential. So far, the country has exploited only 35% of the total potential. Total hydro power reserves are estimated to be around 3000 MW. Potential annual generation may reach up to 10 TWh (Austrian energy agency, 2005).

The total installed capacity in Albania at the end of 2008 was 1684 MW, with a hydro power capacity 1448 MW making 87,2% of it.

Albania suffers from a deficit of electric power, and is today a net importer. The produced electric energy is mainly generated by hydro power plants. Therefore the domestic supply is highly dependent on hydrological conditions.

The different installed HPP capacities and annual generation is given in table 2. As can be seen the largest amount come from the Drin River in north of the country, where Fierze, Koman and Vau Dejes is located.

Power Plants	Installed Capacity [MW]	Annual Generation [GWh]
Fierze	500	1600
Koman	600	1800
Vau Dejes	250	900
Ulza	24	100
Shkopeti	25	95
Bistrica 1&2	28.5	135
Other	20	100
Total	1448	4730

Tabel 2 HPP installed capacity and annual generation (Sommerfeldt, 2009)

The total installed capacity in Thermal Power Plant (TPP) in 2005 was 213 MW. But only Fier TPP is actually working with reduced capacity of 12-20 MW from the existing 159 MW (Sommerfeldt, 2009).

Looking at Albanias total generation from 1992-2007 in Figure 8 it is easy to see the big role played by hydro power and especially Drin River.

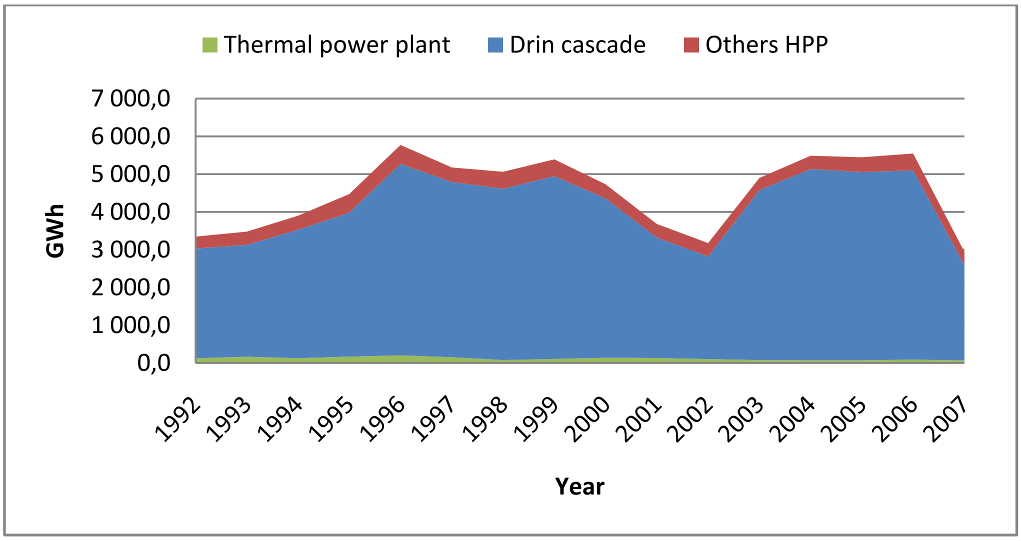

Figure 10 Production in GWh distributed into thermal power plants (green area) and hydro power plants (red and blue area). Where the red area is the production in the Drin river cascade (Albania, 2009)

5.1 Demand

In the early 1990s Albania was virtually 100% electrified and the country was a net electricity exporter, with exports of around 20% of the domestic generation. By 1992 the demand within Albania had fallen to 79% of the 1989 level of 3 514 GWH because of declines in industrial production. Thereafter the demand rose substantially per year to 6 300 GWh in 2008. From 1992 until 2002 the demand had doublet, thereafter it increased another 14% from 2002 until the 2008 level. This increase was mainly due to a sustained surge in consumption by residential and commercial consumers (Karapici, 2009).

The consumption from 2002-2008 is shown in Figure 9. 2007 was a dry year with a low production of only 2 933 GWh. It was impossible to import the remaining electricity demand which saluted in 1 TWh load shedding.

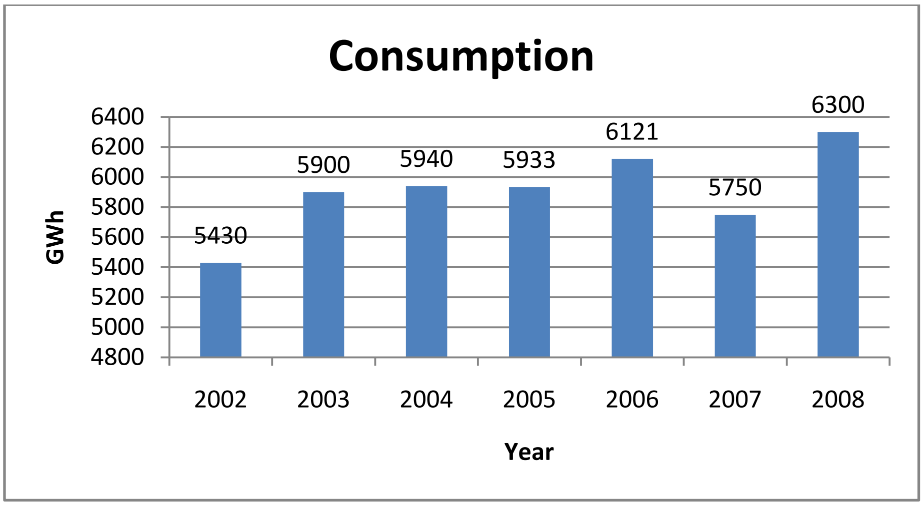

Figure 11 Consumption in Albania 2002-2008 (Albanian Electricity Regulatory Authority Report 2008, 2008)

The need for electricity will continue to grow and the estimated demand in 2010 is 8 000 GWh (Albanian Electricity Regulatory Authority Report 2008, 2008).

Variation of load over the year is not very high compared to Western Europe. Albania has cold winters and hot summers which gives the need of heating in the winter and cooling in the summer, hence the low variation over the year. This can be seen from Figure 10. The red line is the mean load each month, the blue line is maximum load within each month and the green line the minimum load within each month.

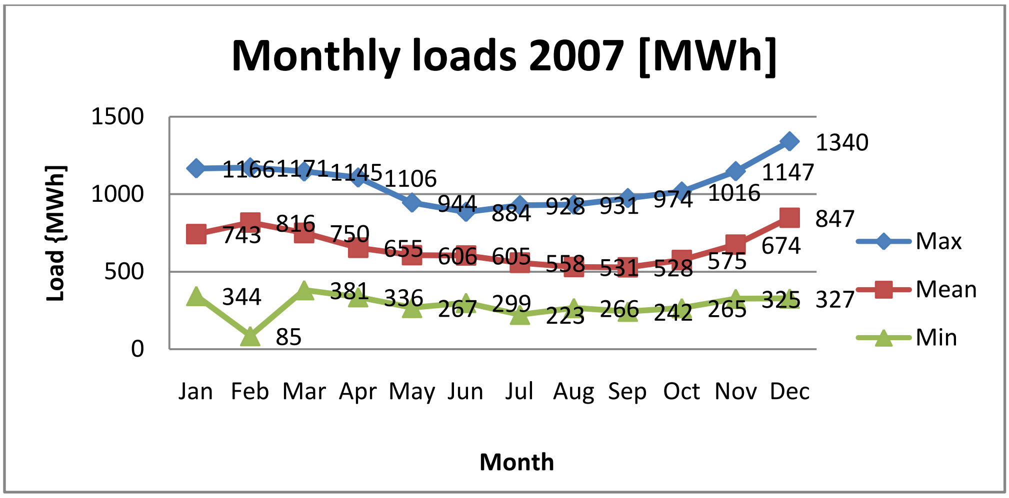

Figure 12 Monthly loads in Albania 2007 (Bredo Erichsen, 2009)

As can be seen in Figure 11 the daily loads have three spikes one in the morning around 8 o'clock and two in the evening, around 17 and 22 o'clock. Figure 11 have two blue lines each shows the day with highest and lowest load in 2007.

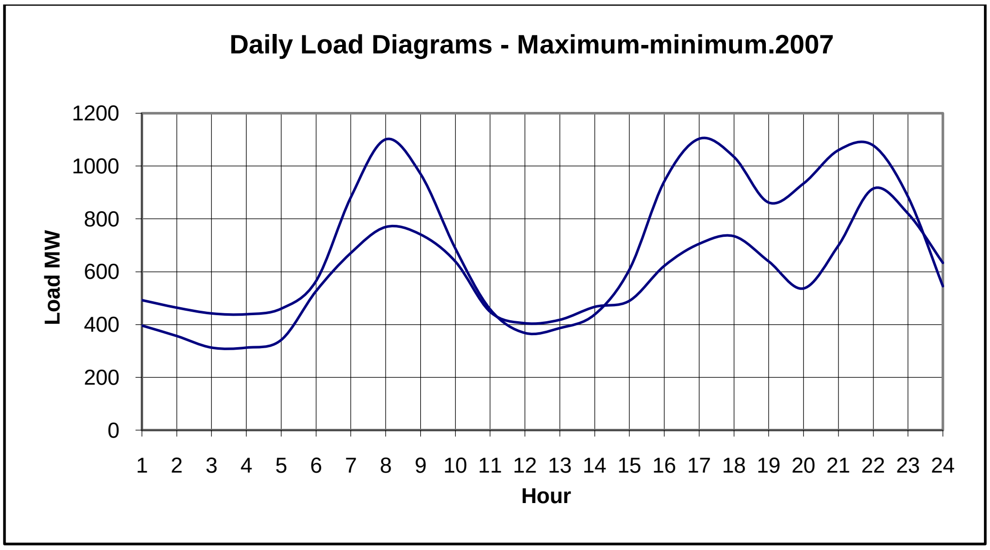

Figure 13Daily loads in 2007, highest curve represents the day with maximum load and lowest curve the day minimum load in 2007 (Bredo Erichsen, 2009)

5.2 Import/Export

From being a net exporter of electricity until 1997, Albania has had to import increasing quantities of electricity. As mentioned before Albania today suffers from a deficit of electric power, and the country is therefore a net importer of energy.

Table 3 shows the import- export balance in GWh for Albania for the period 2005-2008.

Month	1	2	3	4	5	6
2005	-20	6	25	16	69	2
2006	-115	-93	3	80	71	9
2007	-259	-311	-289	-211	-167	-179
2008	-257	-248	-285	-161	-138	-191

Month	8	9	10	11	12	Sum
2005	-54	-36	-97	-139	-251	-567
2006	-74	-60	-98	-68	-189	-637
2007	-233	-220	-263	-250	-262	-2830
2008	-195	-205	-186	-224	-219	-2433

Table 3 Export- Import balances 2005-2008 in Albania in GWh (Nesic, 2009)

The energy is imported from Greece, Montenegro and Serbia. As can be seen from table 3 and figure 12, 2007 was an especially dry year, and not representative as an average export/import balance. 2008 follows with a lot of import since the reservoirs had a low level after 2007.

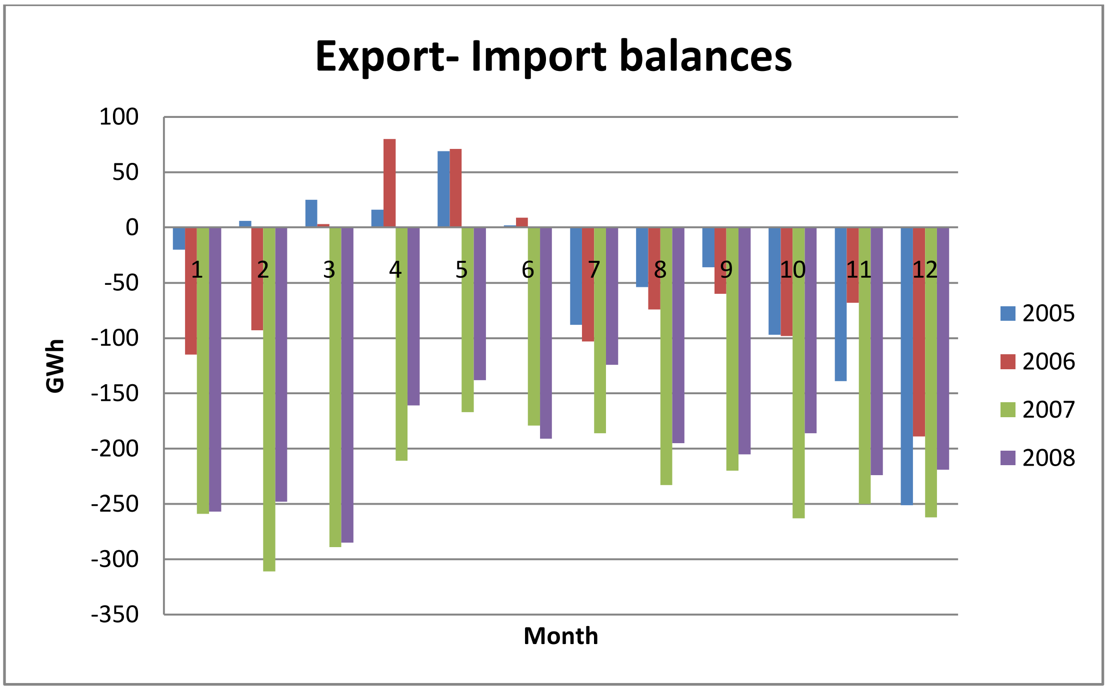

Figure 14 Import balances 2005-2008 in Albania

Since the demand keep on growing and new power generation capacity is insufficient, Albania will very likely continue to need electricity import.

5.3 Power outages

Albania suffers from a large amount of power outs. There are four main reasons for the power outs in Albania.

- Lack of subsidies to finance the needed amount of imported electricity
- Bottleneck in the system when large amounts of import is needed
- Overload in the transmission grid
- Lack of a regulator to take unforeseen supply spikes in the system.

As formerly explained, KESH gen receives subsides from the government to afford to import energy. In dry years this subsides are not enough. In 2007, as shown in table 4 the total planned consumption was 6,8 TWh. 2,9 TWh was produced and 2,8 TWh was imported. Based on expected demand the load shedding was 1,1 TWh.

	Expected demand[GWh]	Load shedding[GWh]	Real consumption[GWh].
Jan	694	-140.2	553.846
Feb	601	-50.6	550.434
Mar	635	-75.6	559.418
Apr	568	-95.3	472.732
May	494	-42.9	451.116
Jun	472	-36.5	435.485
Jul	470	-53.4	416.595
Aug	465	-68.0	396.991
Sep	445	-62.9	382.100
Oct	556	-125.5	430.461
Nov	710	-223.5	486.543
Des	750	-118.1	631.931
Total year	6860	-1092.3	5767.653

Table 4 Production plan, load shedding and real consumption in 2007 (Bredo Erichsen, 2009)

Electricity shortages are a particularly problem in winter with power cuts at times lasting throughout the working day. Shops and other small business can survive these with candles and generators, but power hungry factories have no alternative but to send their workers home. (Albanian Guide, 2009) Thus it is practically impossible for business to grow when the state owned company KESH gen cannot guarantee them power supply.

Since the REM at Balkan still hasn't managed to become successfully developed, purchases from external suppliers (Import) are made under a transparent auction or competitive bid process. These auctions and bids are done some time ahead, and are flat.

PART 2: PRESENT

In this part the present situation of the selected power plants is presented. The optimization of the power plants is then simulated in the EOPS model under today's market regime.

6 HPPs in the Drin

KESH gen is the company that owns and operates the HPP in the Drin which is the main focus in this study. KESH has also contributed with data series and information about the power plants, which was used in the simulations.

The excellent hydrologic and topographic conditions for energy generation on the Drin River was identified early, and has led until present to the construction of five hydropower plants, two in Macedonia and three in Albania.

The Drin River starts in Macedonia where the HPP Globocica and Spilje-Debar are located. Globocica and Spilje-Debar have an installed capacity on 42 MW, respectively 69 MW. The power plants in Macedonia are not taken into consideration in this study (KESH).

The HPP in the Drin in Albania is Fierz, Koman and Vau Dejes, as can be seen on the map below. Together these three plants represent 82% of Albania's total generation capacity of 1640 MW and account for 98% of its national energy production.

Figure 15 Map showing location of HPP in Drin (Statkraft, 2007)

6.1 Annual production of the Drin cascade

From the simulation program EOPS the annual production will be given as one of the results. It is therefore important to find the annual production of today so the analysis gets reliable.

There have been found a number of different annual productions from different sources as showed in table 5.

	(Gana Gjini, 2009)	(KESH)	(Austrian energy agency, 2005)	(Sommerfeldt, 2009)
Fierze	1200	1800	1800	1600
Koman	1800	2000	2000	1800
Vau Dejes	900	1100	1000	900
Drin river cascade	3900	4900	4800	4300

Table 5 Different sources showing annual production in Drin

Hence the variance in annual production from different sources production data received both from KESH gen and the government was studied. The data are given in table 6.

Year	Vau Dejes [GWh]	Fierze[GWh]	Koman[GWh]	Total cascade[GWh]
1986	1 095.2	1 854.9	1 424.6	4 374.7
1987	888.8	996.1	1 758.7	3 643.6
1988	804.8	906.9	1 575.4	3 287.1
1989	815.3	1 044.5	1 601.2	3 461.0
1990	621.5	638.5	1 251.4	2 511.4
1991	699.7	999.7	1 379.8	3 079.2
1992	678.4	839.4	1 387.8	2 905.6
1993	704.3	824.4	1 432.5	2 961.2
1994	781.0	1 032.7	1 585.5	3 399.2
1995	924.2	1 039.2	1 850.6	3 814.0
1996	1 035.5	1 857.2	2 178.2	5 070.9
1997	1 017.0	1 596.1	2 026.3	4 639.4
1998	1 081.8	1 373.3	2 080.8	4 535.9
1999	1 113.2	1 432.9	2 293.3	4 839.4
2000	947.3	1 357.7	1 913.3	4 218.3
2001	776.5	884.4	1 526.6	3 187.5
2002	661.2	746.1	1 335.7	2 743.0
2003	974.0	1 558.0	1 969.0	4 501.0
2004	1 109.0	1 807.6	2 146.0	5 062.6
2005	927.3	1 870.0	2 186.9	4 984.2
Average	**882.8**	**1 232.9**	**1 745.2**	**3 860.9**

Table 6 Production in Drin [GWh] (Albania, 2009)

Average production in the Drin from 1986-2005 is 3 860,9 GWh. These historical data will be used in comparison with the later on simulated production.

The production distribution is shown in figure 16 below. Koman is the plant producing the largest amount of energy, with 45% of the total production in Drin.

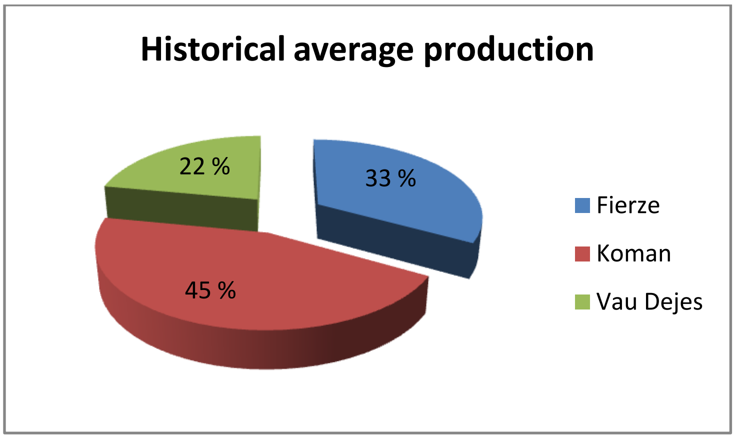

Figure 16 Distribution of production in Drin cascade

The hydrology can vary a lot in Albania, even though the Drin is said to be stable. To make sure that there are no extremely dry or wet years that makes the average production unrealistic, the two highest and lowest production years (1996, 2004, 1990 and 2002) were removed. The new average production became 3 805,1 GWh. It only differs from total average by 55,8 GWh which is not much. The total average production therefore stays as the comparing number in the simulation part of this study.

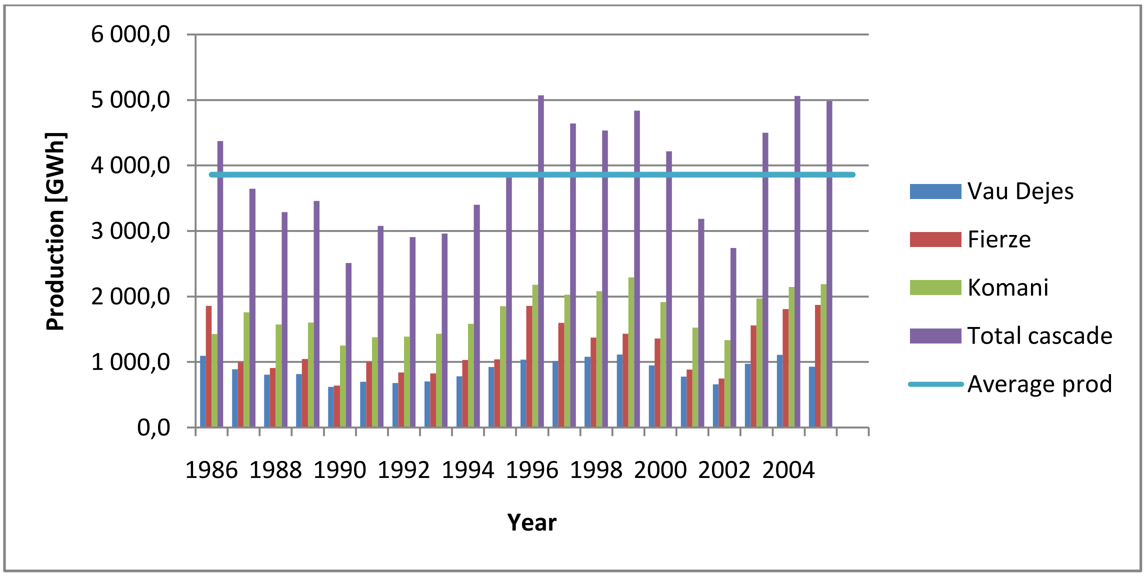

Figure 17 Production in Drin compared with average production in Drin

As can be seen from figure 17 there are no years with extremely high or low spikes that immediately separate from the other years.

It has been a great challenge to collect good data. KESH has only done electronic registration the last few years, and the data they wanted to share has a bad dissolution (only on monthly basis). The received datasets are not always consistent, meaning that for one power plant only reservoir level was given for another the only available data series spillage. This is solved by using the most reliable data series that covers the same subject for all three power plants.

To get a better understanding about these three HPPs, each HPP with its technical specifications and historical production will now be presented. Historical production for each of the three HPPs were individually studied

The most detailed information that has been possible to obtain was on monthly basis in the period from July-06 to January-09. This production cannot be used directly to compare with the simulated production later in this study, but it is an indication on how they utilize their reservoirs.

6.2 Fierze

The Fierze hydropower station is constructed in the valley of the Drin River, near the Fierzea village. Fierze HPP was the second hydro power station constructed in the Drin. The constructing period was 1971-78 and Fierze was set in operation in 1979. (Degennaro, 1999)

6.2.1Technical specifications

Fierze dam is a 177 m rock fill dam with clay core, the dam creates a reservoir with total active storage of 2300 Mm3. Since this reservoir is large and placed at the top of the three power plants in Drin, the reservoir serves as a head pond for the Drin River cascade (Degennaro, 1999).
The station has four Francis turbines installed, each with a capacity of 125 MW. Other technical specifications are seen from table 7.

Units		
Type	Francis	
Number	4	
Capacity	125	[MW]
Total capacity	500	[MW]
Plant flow	475	[m3/s]
Nominal net head	120	[m]
Plant factor	28	[%]
Turbin efficiency	91	[%]

Table 7 Technical specifications, Fierze HPP (Gana Gjini, 2009)

As can be seen from table 7 the plant factor for Fierze is 28%. The plant factor is a value used to express the average percentage of full capacity used over a given period of time. 28% is a relatively low plant factor, which means that Fierze has a high degree of freedom to choose when to produce.

6.2.2 Historical production

The last years of production with belonging reservoir level are presented in the graph in figure 18 below. The level axe shows min- LRV and max-HRV with the corresponding green line to show the water level in the reservoir at each month.

The blue columns show the production in MWh each month and refer to the second axe.

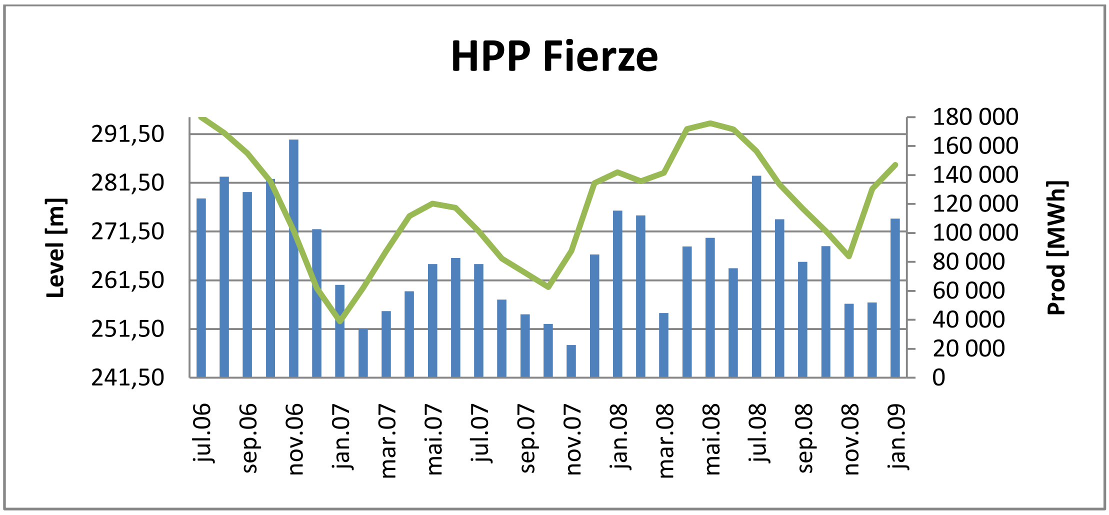

Figure 18 Production in Fierze on monthly basis compared with reservoir level (Gana Gjini, 2009)

It would have been interesting to look at the production/level compared with inflows to see if the reservoirs are utilized regarding spring floods and moving of water from one month or year to another. But data series regarding the inflow were not possible to obtain.

6.3 Koman

The hydropower station of Koman is located in the mouth of Melguni, about 2 km North West of Koman village, between Fierze and Vau Dejes HPP. Koman was constructed in the period 1980-1985 and put in operation in 1986 as the newest of the three HPP in the Drin (Degennaro, 1999).

6.2.1Technical specifications

The reservoir has a total active storage of 200 Mm3 water. The station has four Francis aggregates installed, each with a capacity of 150MW. Other technical specifications are seen from table 8.

Units		
Type	Francis	
Number	4	
Capacity	150	[MW]
Total capacity	600	[MW]
Plant flow	600	[m3/s]
Nominal net head	101,5	[m]
Plant factor	34	[%]
Turbin efficiency	93	[%]

Table 8 Technical specifications, Koman HPP (Gana Gjini, 2009)

Like Fierze, Koman has a low plant factor which implies a high degree of freedom for the energy management. On the other hand the reservoir size limits the flexibility, since the size makes it difficult to save and move water from one time period to another.

6.3.2. Historical production

The production and level graph for Koman is showed below in figure 19.

By comparing the graph from Fierze with the graph for Koman, one could see how Koman's production is dependent on Fierze's production. The production profiles are quite similar. The relative reservoir levels also seem to be corresponding.

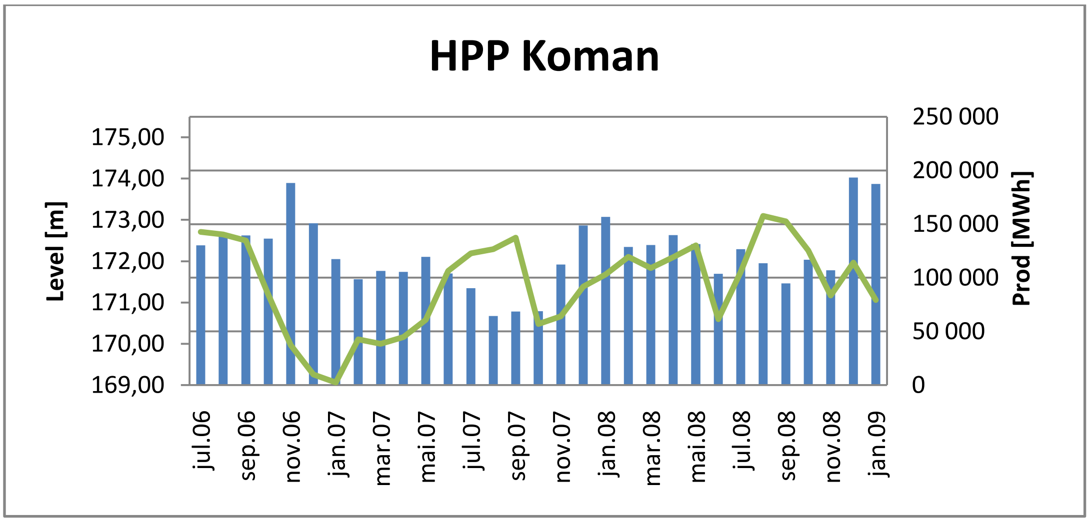

Figure 19 Production in Koman on monthly basis compared with reservoir level (Gana Gjini, 2009)

6.4 Vau Dejes

Vau Dejes is the lowest plant in the Drin river cascade and it was built in the last rocky mouth of the river, 18 km from the city Shkodra. Vau Dejes was the first HPP constructed in the Drin during 1967-1971. It has been total rehabilitated and was finished in October 2007 (Degennaro, 1999).

6.4.1Technical specifications

The reservoir has a total active storage of 250Mm3. The station has five Francis turbines installed, each with a capacity of 50 MW. Other technical specifications are seen from table 9.

Units		
Type	Francis	
Number	5	
Capacity	50	[MW]
Total capacity	250	[MW]
Plant flow	500	[m3/s]
Nominal net head	54	[m]
Plant factor	41	[%]
Turbin efficiency	90	[%]

Table 9 Technical specifications, Vau Dejes HPP (Gana Gjini, 2009)

6.4.2 Historical production

For Vau Dejes power plant more data series were available. This can be seen on the graph in figure 20 below, where a longer series of production, spillage and reservoir level on a monthly basis is shown. The blue colon is the production and the red is spillage, these correspond to the second hand axe. The green line shows the reservoir level and corresponds to the first hand axe.

There are almost no variations in the reservoir level, this is most likely to done keep the head as high as possible resulting in more power.

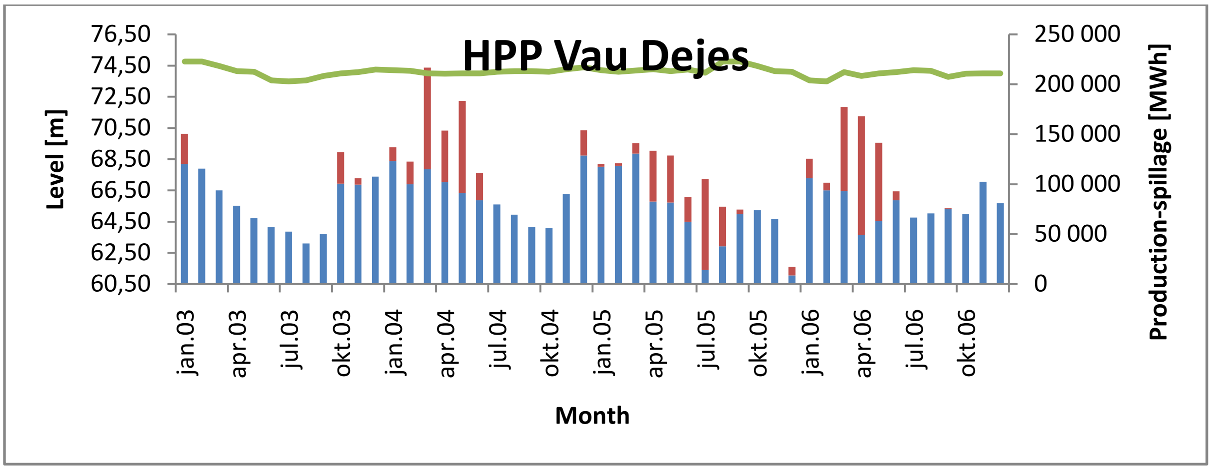

Figure 20 Production and spillage in Vau Dejes compared with reservoir level (Gana Gjini, 2009)

From the graph it can be seen that there are large spikes with spillage each spring around April. Vau Dejes is as mentioned a small reservoir and it is not able to handle the spring flood alone, this must be done further up in the cascade. Since the spillage comes regularly each year it looks like the energy planning is on a very short term basis, and the reservoirs are not prepared to take the spring flood.

6.5 Generation planning in Albania

As mentioned before there is no liberalized power market in Albania at the time being. The price is regulated by ERE and set totally flat. Hence the lack of possibility to buy and sell spot power, all additional energy needed to cover the demand must be imported through contracts.

The objective for power generation scheduling should usually be “utilizing the available generation resources to satisfy the demand for electricity in such a way that the optimal result is obtained and all relevant constraints are satisfied.” Optimal result here means minimizing the generation cost, given an expected demand.

One could claim that the present power market in Albania is quite similar to the one in Norway before the restructuring of the power market in the 1990’s.

Albania has a lack of power, forcing the country to import large quantities when the financials allows it to do so, otherwise they have to ration. This creates both huge import costs, and large cost of rationing inflicted on the society.

Albania almost always suffers from the power deficit, therefore KESH gen usually produces the maximum potential whenever water is available.

Import quantity is politically decided to a great extent. The financials to cover the import cost comes from the government, thus they have a lot to say.

In dry years like 2007, KESH gen faces big challenges. With no water available and no money to finance the import, load shedding is the only opportunity. The production planning turns into planning which part of the country the electricity should be cut off and at which time.

KESH gen is today working on establishing an energy management department (Gana Gjini, 2009).

7 Simulation of production

In this part the EOPS model explained in part 1, was used to simulate the production in the Drin river system. Thereafter the simulated production was compared with historical production.

7.1 Simulation setup

The establishment of the EOPS model and how the simulations are executed is presented in this sub chapter.

The simulations will be executed in the system called DRIN. Important figures of the system is presented in table 10.

First year of analyzed period	2009
Number of years of analyzed period	1
First year of historical data	1953
Number of years of historical data	53
Number of price segments	4 [2]

Table 10 system data, in the SYS selection in the model

As explained in part 1 this study seeks to find the optimal use of the hydro power resources in Albania. For this purpose the simulation will be done in series. The simulation parameters are given in table 11.

First week of simulation period	1
Last week of simulation period	52
Number of inflow scenarios	53
Period of inflow scenarios	1953-2005

Table 11 simulation data

7.2 Power plant and river system data

Most of the technical specifications are given in table 4-6.

The power plant modules need in addition to the given technical specifications the reservoir volume, energy equivalent, reservoir curve and PQ curve. These specifications for each plant are given in appendix C.

The hydrology is represented through one historical series on daily basis for the river stream and an average volume per year for inflow.

<u>Series</u>

On early simulations the hydrology series 3554-R where used, this covers the Black Drin in the period 1955-1990. Since the historical production is only given from 1986 (When the HPP where set in operation) it is only four years that can be compared. And since these years vary a lot, see Appendix D, other series were considered.

[2] The numbers of price segments are 4, but since the price is set flat only 1 will be used.

It was decided to use the series 3551-R, this series is for the Devoll river stream. Black Drin River is located close to Devoll and has quite similar topography. The simulated production with the 3551-R series is similar to the production with the 3554-R series. 3551-R covers the years 1953-2005 which gives a longer comparison period.

<u>Volume</u>

The volume was found from a historical inflow series for Fierze (1948-1969) (Ericksen). The mean inflow that period was 6800 Mm3/year. The volume for Koman and Vau Dejes were found by multiplying a factor given from Statkraft with the volume for Fierze. The volumes and factors are presented in table 12 below.

	Fierze	Koman	Vau Dejes
Factor(% of Fierze)	100 %	146 %	153 %
Inflow (Mm3/year)	6800	9942	10389
Inflow per HPP (Mm3/year)	**6800**	**3142**	**447**

Table 12 Inflow volumes for each HPP to the EOPS model

7.3 Market data

As explained there is no present market in Albania. The price is set flat at 10 EUR/MWh and there is no opportunity to sell or buy power on spot market.

Since there are no price forecast that reflects the market components that affect the planning had to be put manually into the model.

Contractual obligation - Demand

Firm demand over the year was set to 2008 level at **6300 GWh/year**. The profile over the year comes from 2007, showed in table 13. For the calculations see appendix E.

Week	Relative value	Week	Relative value	Week	Relative value	Week	Relative value
1	1.13	**14**	0.996	**27**	0.849	**40**	0.803
2	1.13	**15**	0.996	**28**	0.849	**41**	0.875
3	1.13	**16**	0.996	**29**	0.849	**42**	0.875
4	1.13	**17**	0.996	**30**	0.849	**43**	0.875
5	1.241	**18**	0.922	**31**	0.849	**44**	0.875
6	1.241	**19**	0.922	**32**	0.808	**45**	1.025
7	1.241	**20**	0.922	**33**	0.808	**46**	1.025
8	1.241	**21**	0.922	**34**	0.808	**47**	1.025
9	1.141	**22**	0.922	**35**	0.808	**48**	1.025
10	1.141	**23**	0.92	**36**	0.808	**49**	1.289
11	1.141	**24**	0.92	**37**	0.803	**50**	1.289
12	1.141	**25**	0.92	**38**	0.803	**51**	1.289
13	1.141	**26**	0.92	**39**	0.803	**52**	1.289

Table 13 Demand profile given in each week

The profile is shown on figure 10 in part 1.

Price dependent market

Import

Since there is no present spot market, the additional power must be imported. The import is decided in bid auctions, the simple model implementation is shown in table 14.

Import	Volume (GWh/week)	Price (EUR/MWh)
day	50	25
night	15	11

Table 14 Allowed import volume and price

The volume calculations are shown in Appendix E.

The import price was not possible to find, so it is set as logic as possible, high volume and price during the day and low at night.

Export

When the model has aimed to cover the demand it is allowed to export surplus production. The exported energy was not given a price.

Rationing

Rationing is a big problem in Albania. Because of the lack of power during day time industry have to be shut down occasionally, the costs this reflect on the society are high. This is implemented in the model by high rationing costs. The rationing curve is stepwise, higher volume rationing has higher costs. The lowest step has a price ten times the price of produced power. The rationing steps are shown in table15.

Rationing step	Price (EUR/MWh)	Volume (%)
1	107.5	3
2	122.5	3
3	140.0	4
4	172.5	2.2
5	227.5	3.1
6	291.6	3.1
7	391.8	6.6
8	460.0	75

Table 15 Rationing cost at different step

Additional power

At the time being there is not much power generation in addition to the Drin. Only some other small scale HPP and one thermal plant exist. The TPP is almost never in operation.

Most of the small scale HPP's are run of river and the owners don't do much planning. The additional power is therefore set as a base load on 5,5 GWh per week with a low price at 5 EUR/MWh, showed in table 16.

Additional power	Volume (GWh/week)	Price (EUR/MWh)
	5.5	5

Table 16 Additional power from small hydro power and thermal power plant

7.4 Test simulation- production in dry and wet years

To see how the model handles extremely dry and wet years the 0 percentile and 100 percentile (for inflow) were studied.

The results for the 0 and 100 percentile are presented below in table 17.

	0 %	100 %
Inflow [GWh]	1643	9971
Flood [GWh]	0	3385.9
Delivered power [GWh]	1566.2	6988.5
Not delivered power [GWh]	1067.8	0
Export [GWh]	0	1313
Import [GWh]	3666	661.9

Table 17 Results from test simulation, dry and wet year

In the dry year the model only produces 1566,2 GWh. It imports 3666 GWh which is the highest amount allowed to import. The remaining demand is not possible to cover, resulting in 1067,8 GWh load shedding.

In the wet year the model delivers more than the 6300 GWh contractual demand. The model imports 661,9 GWh, probably because of the demand profile. It is not able to cover the demand itself each month and has to import. In the months where the demand is covered, there is still more water left, hence the model exports 1313 GWh in total.

8 Simulation results

The results for annual production in the simulation period are given in table 18.

Annual production from EOPS		
Fierzes	1787	GWh
Koman	2275	GWh
Vandejes	1173	GWh
Total Drin	5235	GWh

Table 18 Annual productions from the EOPS model

The percentage distribution is shown in the pie diagram in figure 21 below. It is still Koman that has the largest amount of production with 44 % of the distribution.

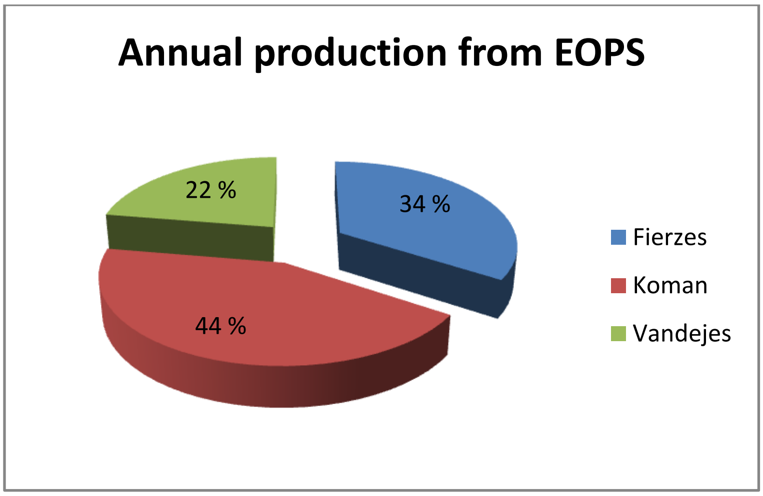

Figure 21 Distribution of annual production from EOPS

The simulation period is much longer than the time period the hydro power plants have existed. At the same time the hydrology trend shows sinking precipitation. There for it is mostly interesting to study the period where data for both historical production and simulation exists: 1986-2005. The results are given in figure 22 below. The red line is historical production, this is previously given in table 6. The blue line is the simulated inflow and the green line simulated production.

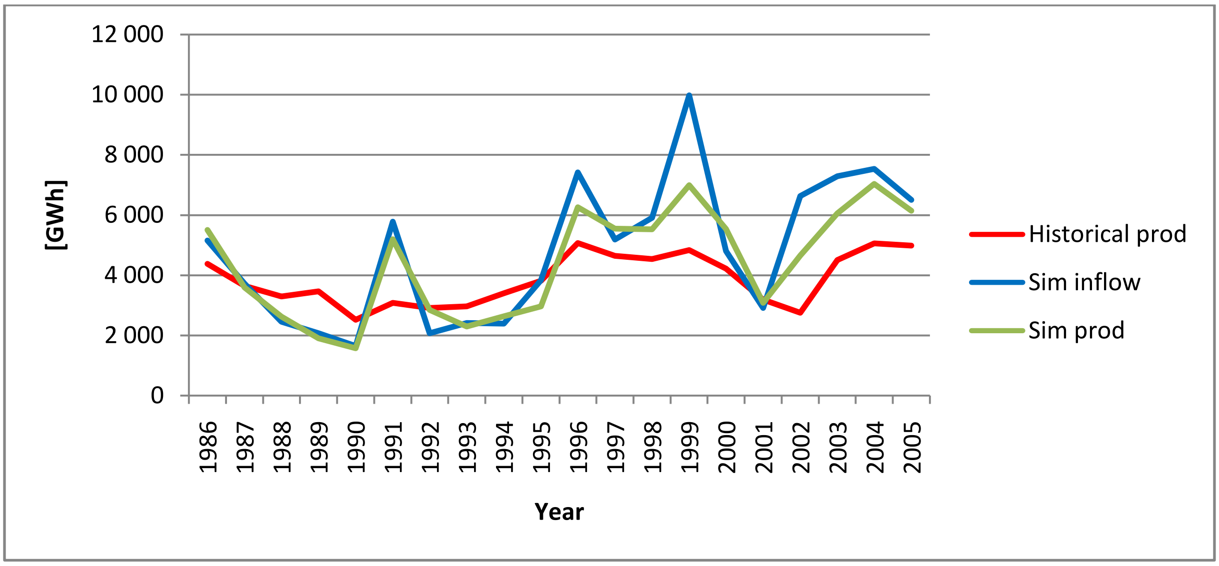

Figure 22 Comparing historical production with simulated production and inflow

As can be seen from the blue line the years 1987-1990 and 1992-1995 was very dry. How the Albanians could produce the historical values those years has been difficult to explain. The possibility of moving water from one year to another has been looked at, but this is not possible with the size of reservoirs and such a high variance between inflow and historical production. One possible reason can be that the data quality before 1996 is not very good, both on the production side and the hydrology side. To get good data sets this far back can be difficult even in the Nordic countries.

Since the data set before 1996 doesn't seem to be reliable only the results for the period 1996-2005 will be presented and used further on in this study.

The simulated inflow and production for this period is given in table 19.

Year	Inflow[GWh]	Fierze[GWh]	Koman[GWh]	Vau Dejes[GWh]	Total Drin[GWh]
1996	7 412	2 150	2 689	1 413	6 253
1997	5 178	1 959	2 348	1 239	5 546
1998	5 906	1 908	2 361	1 250	5 520
1999	9 971	2 538	3 001	1 448	6 988
2000	4 798	1 969	2 350	1 212	5 532
2001	2 906	891	1 435	746	3 072
2002	6 626	1 419	2 142	1 085	4 647
2003	7 288	2 180	2 569	1 303	6 052
2004	7 529	2 509	2 988	1 533	7 031
2005	6 494	2 177	2 592	1 365	6 135

Table 19 Simulated inflow and production

The differences in production in 1996-2005 are illustrated in figure 23 below.

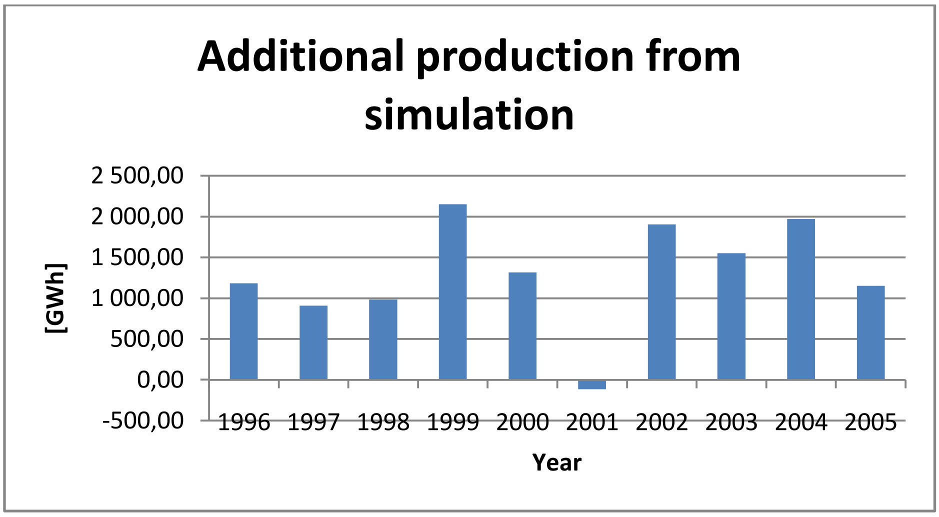

Figure 23 Additional productions from simulation

The model produces more than the historical production every year except 2001. Hence 2001 was a dry year the model has low production, but KESH gen could have moved water from 2000 and produced it in 2001. Since the additional production from the simulation is almost 2 TWh in 2002, it is possible that KESH gen produced all available water in the reservoirs in 2001 and used 2002 to fill the reservoirs. 1999 was a wet year and the year where the variance between the model and the historical data are highest. Production planning is important in wet years to avoid spillage, and is hence the years that reflects the highest improvement potential.

As explained earlier the annual productions varied a lot, and it was therefore decided to use average production (time period 1996-2005) for comparison. This is showed in table 20.

	Drin	Fierze	Koman	Vau Dejes
Average sim [GWh]	5 678	1 970	2 448	1 259
Average hist [GWh]	4 378	1 448	1 965	964

Table 20 Average production historical and simulated

An average year the production in Drin is through simulation increased with 1.3 TWh. Taking into consideration that the total production in Albania is approximately 4.7 TWh this is an improvement potential of 30%.

Each power plant was looked at and compared with the historical production to analyze where the utilization potential is largest. Average potential of improvement under the current technical conditions is given in table 21.

	Average potential of improvement [%]
Fierze	0.25
Koman	0.18
Vau dejes	0.22

Table 21 Average potential of improvement

Fierze produced on average 25 % more in the simulations than historical, hence has largest utilization potential in the Drin river. Followed by Vau Dejes with 22% and Koman with 18%.

Looking at the utilization of the reservoir, in figure 24-26, Fierze is used similarly in dry and wet years. Koman follows Fierze with a little lag while Vau Dejes stays stable around 74 masl, this was mentioned earlier, explained by the level giving more head.

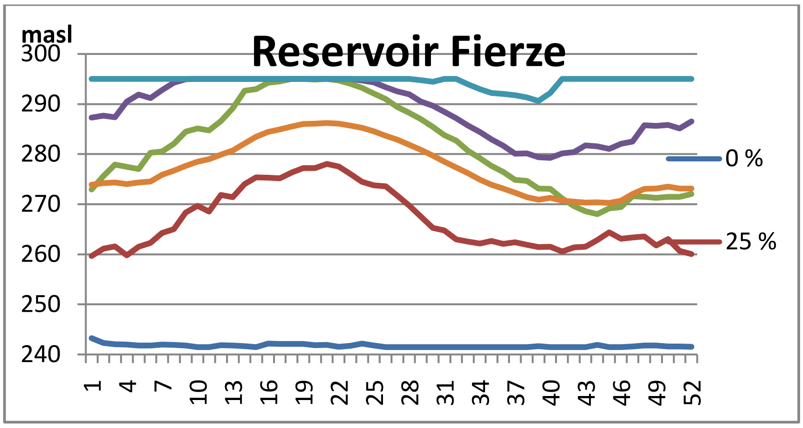

Figure 24 Simulated reservoir level in Fierze

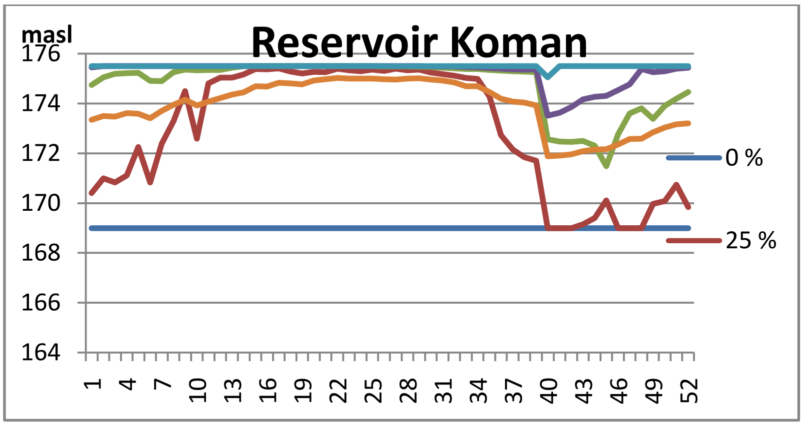

Figure 25 Simulated reservoir level in Koman

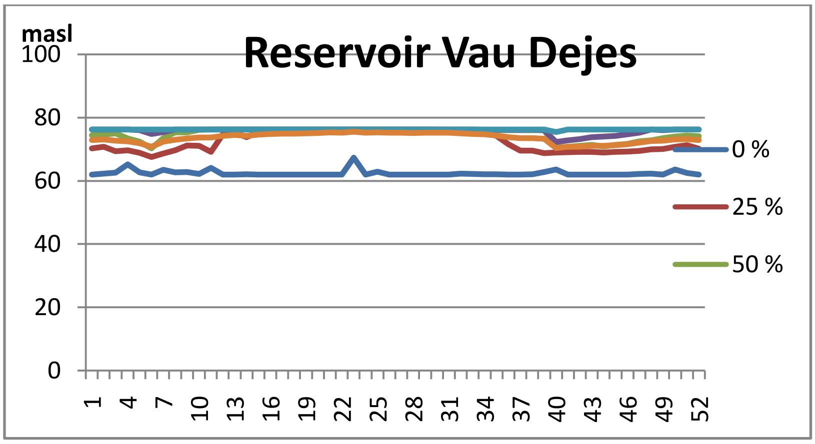

Figure 26 Simulated reservoir level in Vau Dejes

8.1 Discussion, part 2

There are several challenges regarding simulating the present situation in Albania. Getting god hydrological series with satisfactory simulation period was one of them. The series that was used are originally from the Devoll river cascade. This series includes 2005, and is therefore 15 years longer than the original series from Drin river cascade. The Devoll series was compared with the one from Drin and the similarities were satisfactory.

Even though the data series seem satisfactory, there were problems explaining what the variation between the historical and simulated production in 1986-1995 could result from. Since the years around 1990 were really dry there is a possibility that the documentation of the production could be wrong. The reason was not possible to discover, it was therefore decided to focus on the time period 1996-2005. This period seems more realistic regarding both hydrology and documented production. The hydrology volume was found from a series for 1948-1969. This might be a little bit high since hydrology reports show that the precipitation has decreased some percent over the long run. Yet the volume was kept since it is impossible to find the precisely decrease and no other series for volume existed.

Another challenge was to model the present market situation in Albania. Albania is still a closed country and data are not given out easily. Several meetings with KESH resulted in inconsistent data series concerning the market conditions. It was not possible to get hold on import tariffs and the exact amount of energy imported to Albania. This task was solved by collecting data for export to and import from Albania from neighboring countries. Concerning the demand, the 2008 level was set to the expected demand. The present demand volume might be higher than the one used in the model, but since the focus was set on historical production when the demand was even lower it swas kept. Concerning the demand profile over the year, 2007 was used in lack of better data series, even though this could not be regarded as a normal year.

More parameters than KESH uses in their planning was implemented into the model, like rationing costs. These costs were set ten times higher the production cost for the first level, with increasing cost when more rationing occurs. The rationing has a high socioeconomic cost for Albania since rationing results in industry closing down. Even though KESH doesn't take it into consideration, it is an issue that producers in Nordic countries must consider.

Test simulations were done to see if the model followed the market conditions in a satisfactory way, looking at dry years where the production could not cover the demand, and wet years where the possibility of export was present. The model seemed to be working as wanted.

The result shows a much higher annual production, but since the latest years wore the primary focus, the average production from these years was used in comparison.

All the power plants showed potential of improvement all years except 2001. The explanation why KESH was producing more than the model this year is moving water from 2000 till 2001.

Final it is important to remember that KESH doesn't have total freedom in their planning, they are under political influence. However, since KESH is the company that must pay for additional imported electricity the incentives for doing good planning should be there to a certain extent.

PART 3: FUTURE

9 Future scenario 2020

As presented in Part 1, under the Energy Market chapter, Albania will during the process of the technical implementation of the Albanian Market Model (AMM) follow the Transitory Market Model (TMM). In this part a future scenario based on the AMM is implemented, and a regional market (REM) is functioning. Also new transmission lines are built, and new power plants are in operation.

9.1 Albanian Market Model, AMM

The Albanian Market Model was approved by the decision of Council of Ministry on October 3, 2007. This approval was an important step towards the consolidation and steady development of the Albanian electricity market. The approval is a part of the reform that the Government of Albania has undertaken for the reconstruction of the electric power sector. The AMM has been developed according to the EU Directives on electricity and the requirements of the energy community treaty of South Eastern Europe for the creation of the regional market of electricity (Athens Memo II), as ratified by the Parliament of Albania in 2006 (ERE, Albanian Market Model).

The Albanian Market Model takes into consideration (ERE, Albanian Market Model):

- The steps that the Government is taking in the process of moving from the vertical integrated structure of the Electricity Sector, towards a structure with legally, functionally and financially separate Generation, Transmission and Distribution entities.
- The political objectives of the Government for starting the process of privatization in the Power Sector.
- The harmonization of the power legislation with that of the EU.
- The development of the electricity market according to clear market rules and grid codes as minimal technical requirements for an efficient operation of the Power System.
- Higher consumer benefits in terms of securing supply of electrical power and quality service.
- The establishment of third party access[3] in order to participate in the electricity market and the creation of the conditions for the development of a transparent and non-discriminatory market.
- The liberalization of the electricity market, creating a market structure that increases the interest and number of participants.
- The monitoring of the electricity market by ERE, as an independent institution, with the authority to approve all the secondary necessary legislation for this purpose.
- The rules for carrying out transaction in the markets that are transparent and non-discriminatory, and possible misappropriation of funds.
- The development of a tariff reform in order to protect the consumers and at the same time to increase the efficiency of the power system of Albania.

[3] The third-party access right in the energy market context is the idea that in certain circumstances economically independent undertakings operating in the energy sector should have a legally enforceable right to access and use various energy network facilities owned by other companies.

- The integration of the Albanian electricity market with the regional market, and later with the European electricity market.

The Albanian Market Model can be updated according to the developments in the electricity sector and the commitments that Albania may undertake in the framework of regional cooperation.

9.1.1 New Market participants

Since the TMM was previously presented, only the new participants and changes in the structure will be described in the next paragraphs.

In the AMM any customer is free to choose whether to be a tariff customer or an eligible customer if he meets the conditions sat by ERE (Haci).

IPP and External suppliers are included in the TMM but are not yet participants in the market. In the AMM they will function as explained in the TMM.

<u>Wholesale public supplier:</u> The entity or division within KESH that purchases the electricity supply from KESH gen, SPPs, IPPs and traders that are required by tariff customers and sells power to the retail public supplier (Haci).

<u>Retail public supplier:</u> The entity that performs the function of purchasing electricity supply from the wholesale public supplier and sells that power to tariff customers. The retail public supplier may be within the distribution company (ERE, Albanian Market Model).

<u>Trader:</u> Domestic or foreign entities that buy and sell electric power at the wholesale market. The traders should be licensed by ERE.

It should be easy for traders to join the Albanian market. ERE shall ensure that the license, and the licensing procedure for traders are simple and non-discriminatory (Haci).

9.1.2 Relationship among market participants

The relationship among, and the role of, market participants in the physical operation of the AMM are to be set forth in bilateral contracts between the various participants.

The contractual relations between the following parts will still be regulated to a certain extent (Haci):

- KESH-gen and wholesale public supplier (at least for the purpose of making transparent prices charged by KESH-gen to the wholesale public supplier)
- TSO and market participants for transmission and related services
- Distribution company and market participants for distribution and other related services
- SPPs/IPPs and the wholesale public supplier
- Retail public supplier and its tariff customers
- KESH-gen and imports contracts for the exchanges of power
- TSO and KESH-gen, SPPs, IPPs
- Traders for the transmission losses

The contractual relations between the following parties will be set trough an unregulated market:

- Qualified supplier and eligible customers

- SPPs/IPPs, qualified suppliers and traders
- Wholesale public supplier and traders
- The distribution company and traders for energy needed to cover losses in the distribution system.

The energy supply agreements are shown in Appendix F

9.2 An open regional market

One of the main tasks with the AMM is to ensure that it can easily be implemented in the regional market (REM). As mentioned in part 1 Albania signed the Athens MOU in 2003 and by doing this they have are committed to cooperate in creating a regional market for electricity (REM) in south east Europe (Kamberi, 2005).

The Athens process came as a result of the European Union taking a more active stance in promoting stability and sustainable development in South East Europe. It, subsequently, set up a proposal outlining the principles and the institutional necessities on which the development of the regional electricity market for the South East European (SEE) area should be based. It ultimately would ensure the integration of the region into the European Union's internal electricity market. Both, the initiative and the approach, were highly welcomed by the countries from South East Europe.

With respect to the regional electricity market, the participating countries committed themselves to establish common rules for generation, transmission and distribution of electricity and to adopt the rules relating to the organization and functioning of the electricity market, access to the networks and the operation of systems as those laid down in Directive 2003/54/EC**1**. The participants were also obligated to provide a timetable for doing so (Energy community, 2009).

In the future scenario Albania is a part of the REM, the market has gone from a regulated tariff market to an open market structure.

9.3 The privatization and deregulation process

Through the Transition to the AMM the energy sector undergoes a privatization and deregulation process. The privatization process has begun. Several of the energy entities like the distribution company have been privatized. But even though this process is in operation, the market is still highly regulated and all the participants have to follow the politically regulated prices by ERE. If there becomes a deregulation of today's market forming a Balkan market the electricity prices will come from the marked equilibrium as in the Nordic market. The private companies can then decide at witch price they are willing to produce and sell power.

One of the main advantages of privatizing the electricity sector is usually to attract private sector investment, to improve operational efficiency and to introduce as far as possible competition.

In the future scenario it is assumed that the process has been accomplished. The market will function more or less like the Nordic market explained in part 1, and the roles and responsibilities are as explained in the AMM.

9.4 New Power Plants

There have been no new investments in electricity generation in Albania since 1984, and as described earlier Albania suffers from a deficit of electrical power. Present several power plants are planned thus the situation will improve.

The known plans for new power plants in Albania are shown in table 21:

Name	Installed Power [MW]	Type	Location
Ashta	40	Hydro	Drin river
Skavicha	246	Hydro	White Drin
Kalivac	100	Hydro	Vjosa river
Devoll	300	Hydro	Devolli river
Vjosa	200	Hydro	Vjosa river
Vlora	97	Thermal	Vlora

Table 22 Planned power plants in Albania (Sommerfeldt, 2009)

Kalivac is already under construction, and Statkraft got the application for a concession in the Devoll valley approved in December 2008. The construction in Devoll will summer 2009. Vlora is an oil-fired power plant, and it will be in operation during 2009.

Since this study focus on the Drin River, the new power plants in Drin will be looked at more closely.

There is still room for two new projects in the Albanian territory as you can see from the figure 27. The first plans for these projects date back to 1960's. Due to lack of financing these projects plans were never realized. Now the plans are again actualized. Bushati HPP is localized in the bottom of the Drin River, and will function as a pure run off river plant. Skavica is located in upper Drin (KESH). The longitudinal profile of Drin is showed in figure 27.

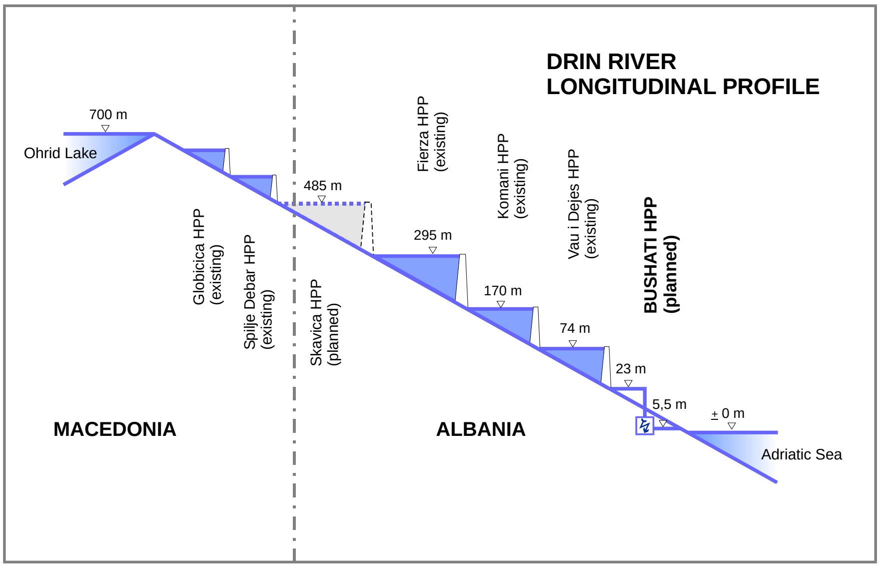

Figure 27 Schematic Length Profile of Drin River Showing Existing and Planned Hydropower Projects (KESH)

9.5 New transmission lines

Bottlenecks are a problem in Albania when the import is high. With increasing demand and new power plants under planning, necessity the building of transmission lines.
The REM also requires that the transmission system to neighboring countries must be upgraded.

Several transmission line projects are under development. A new 400 kV line from Elbasan to Podgorica (Montenegro) is under construction. Two new 400 kV are under planning, one is a cable to Italy and the other a line to Macedonia. Both these lines are assumed completed in 2020.

9.6 Demand forecast

The demand is expected to grow substantially the next years until 2020. Table 23 with the estimated electricity demand and peak load for the period 2009-2020 is showed below.

Year	Electricity demand [GWh]	Peak load [MW]
2009	7065	1440
2010	7273	1483
2011	7491	1527
2012	7716	1573
2013	7947	1620
2014	8186	1669
2015	8431	1719
2016	8684	1770
2017	8945	1823
2018	9213	1878
2019	9490	1934
2020	9774	1992

Table 23 demand forecast (TSO, 2009)

10 Simulation of production

In this part the Drin river system will be simulated in the future 2020 scenario. In this scenario there is a functioning regional market. The price is decided from the market cross as in the theory for the Nordic market in part 1. Since the market has been restructured the objective of the power generation scheduling is to maximize the profits from generation, given a price forecast.

The different parameters that were input in the EOPS model are presented below.

10.1 New HPP in Drin

In Statkrafts proposal for the Skavica project, Skavica HPP is divided into three new power plants: Katundi, Arrasi and Skavica. Downstream Drin there is one new power plant planned, this is Ashta, which formerly was called Buschati. One of the branches will also be used to produce power, this plant is called Bustrice. How the water flows is showed in figure28 below.

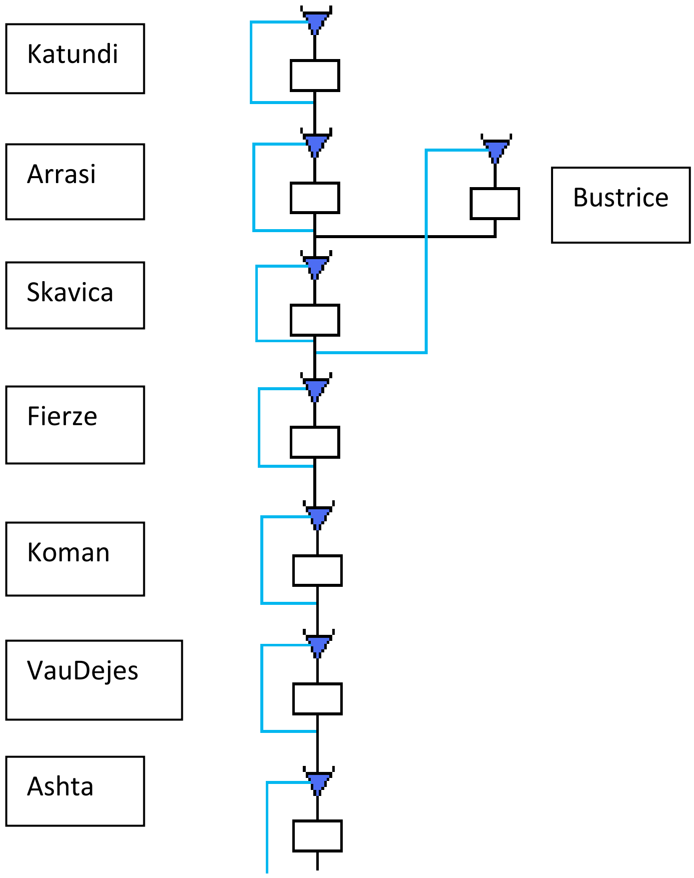

Figure 28 Water flow in Drin

Where

: reservoir

: power plant

: water from diversion flow and flood

: production water

The technical specifications for the new hydro power plants are shown in table 23 below.

	Katundi	Arrasi	Skavicha	Bustriche	Ashta
Inflow [Mm3/year]	2027	243	618	618	409
reservoir volume [Mm3]	112	79	16.4	16.4	2.4
en.ekv [KWh/m3]	0.118	0.063	0.159	0.159	0.028
Plant flow [m3/s]	145	162	247	15	162

Table 24 technical specifications new HPP in Drin cascade (Mossing, 2009)

Since the energy equivalent and plant flow is given the model can run without more specifications on installed power.

The river system scheme from the EOPS model is shown in Appendix G.

10.2 Market

The simulation is done with a price forecast developed by Statkraft, where all the new components are implemented like new thermal power plants, new hydro power plants, new transmission lines and forecast for demand and supply.

Power will be allowed traded in the spot market.

11 Simulation results

When there is a market and a price forecast the model aims to find the highest income through profit maximizing the utilization of the water. It wants to produce when the price is high. The annual production results for the Drin cascade are given in table 25 below.

Annual production from the EOPS		
Katundi	**217.6**	GWh
Arassi	**129.1**	GWh
Skavica	**448.9**	GWh
Fierzes	**1796.9**	GWh
Koman	**2259.9**	GWh
Vandejes	**1143.5**	GWh
Ashta	**261.8**	GWh
Total	**6257.6**	GWh

Table 25 annual production from EOPS

The percentage distribution of production in Drin is showed in figure 29 below.

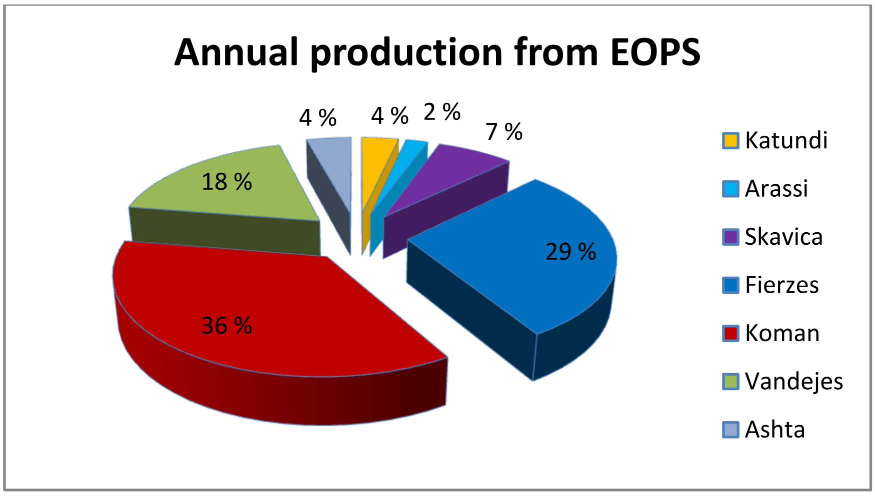

Figure 29 percentage distribution of production

The red piece is Koman, which is still the power plant with the highest production in Drin.

Since the inflow series are historical also the future scenario simulations are interesting to compare with the historical data to see how much more production it could be possible to get with new power plants in the Drin cascade and a functioning market.

Based on the same reason as in part 2 the basis for comparison is 1996-2005.
Inflow, historical production and simulated “future” production for the whole Drin is showed in graph in figure 30 below.

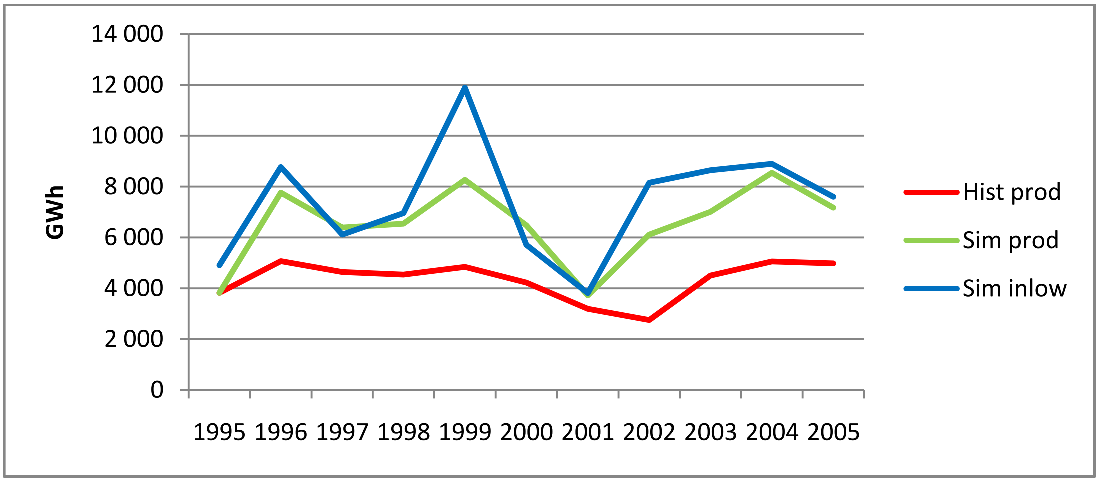

Figure 30 Comparing of historical production with simulated production and inflow

The simulations produce more every year including 2001 which was the only year the simulation of the present situation produced less than historical. The variation between simulated and historical production are highest during wet years. One can see from the green and blue curve how the model moves water from one year to another.

Since there now are four new HPP in the Drin the total productions are different from the historical production as expected. To get the best basis of comparison the focus will be put on the production in Fierze, Koman and Vau Dejes.

The table with the simulated production in these three HPPs is given in table 26 below.

Year	Fierzes[GWh]	Koman[GWh]	Van Dejes[GWh]	Sum[GWh]
1996	2 217	2 798	1 420	6 434
1997	1 873	2 289	1 172	5 333
1998	1 885	2 355	1 221	5 461
1999	2 480	2 991	1 412	6 882
2000	1 932	2 339	1 196	5 466
2001	979	1 362	720	3 061
2002	1 689	2 189	1 088	4 966
2003	2 078	2 526	1 247	5 851
2004	2 542	3 050	1 514	7 106
2005	2 087	2 575	1 299	5 961

Table 26 Simulated production Fierze, Koman and Vau dejes

The production in Fierze, Koman and Vau Dejes should be compared to each other. To see how the production in one plant corresponds to the production in another.

Historical

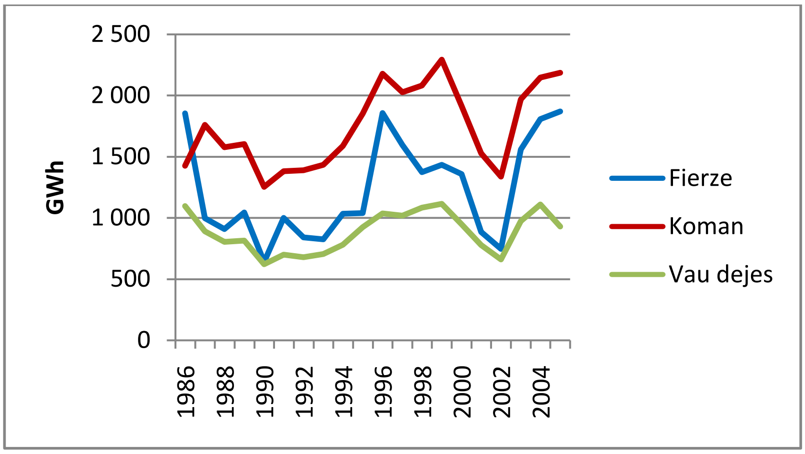

Figure 31 Historical production

Future scenario

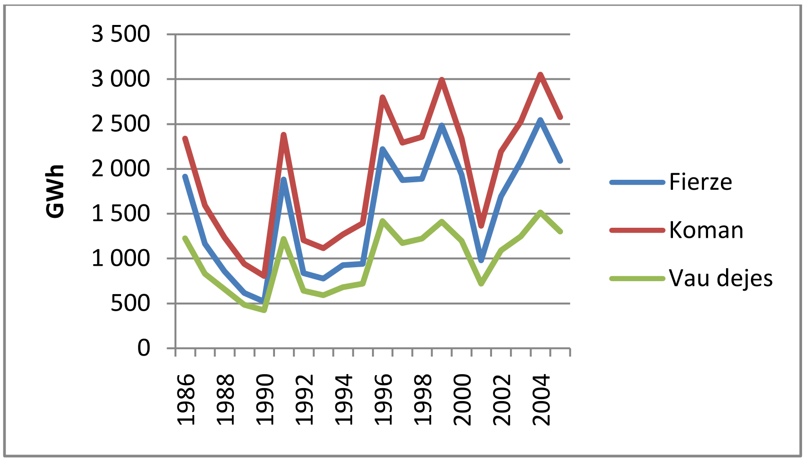

Figure 32 Simulated future production

From these graphs one could see how the power plants in the simulation produce more dependent on one another.

Present vs future simulations

Simulated average productions for the three power plants are presented in table 26 below.

	Fierze[GWh]	Koman[GWh]	Vau Dejes[GWh]
Average sim future	1976	2447	1229
Average sim present	1970	2448	1260

Table 27 Average production

Looking at the average production in Fierze, Koman and Vau Dejes isolated one can see that the production in the future scenario is not higher than the simulation of the present. In fact for Koman and Vau Dejes it is lower. The model aims to get the optimal production in all the power plants in

Drin river, the future scenario having four new plants to consider and a price forecast to run after can explain why the Koman and Vau Dejes have a lower production.

Comparing the production in total Drin river the differences in average production in the two simulated cases are 1022,6 GWh

Difference in total production on a yearly basis is showed in table 28 below

Year	Future sim	Present sim	Difference
1996	7758	6344	1415
1997	6391	5395	996
1998	6541	5155	1386
1999	8261	6719	1543
2000	6475	5138	1338
2001	3718	3032	686
2002	6105	5112	994
2003	6998	5781	1217
2004	8536	7165	1371
2005	7169	5984	1186

Table 28 Comparing of simulated present and future

The differences are illustrated in the figure below.

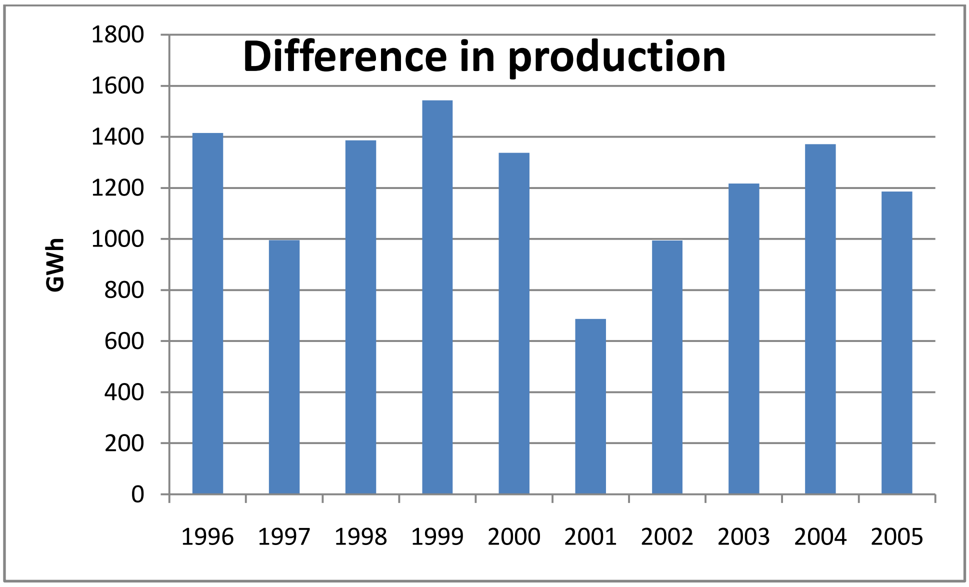

Figure 33 Difference in production between simulated present and future

Every year in the comparison period the future scenario produces more than the present scenario. The highest differences are in wet years like 1999 giving 1.5 TWh more energy. This were expected as the future scenario has more plants and reservoirs in the Drin river and therefore can utilize the water in a more optimal way.

To see how the market and new power plants affects the production planning, the average reservoir level for Fierze in the simulated present and future scenario must be studied.

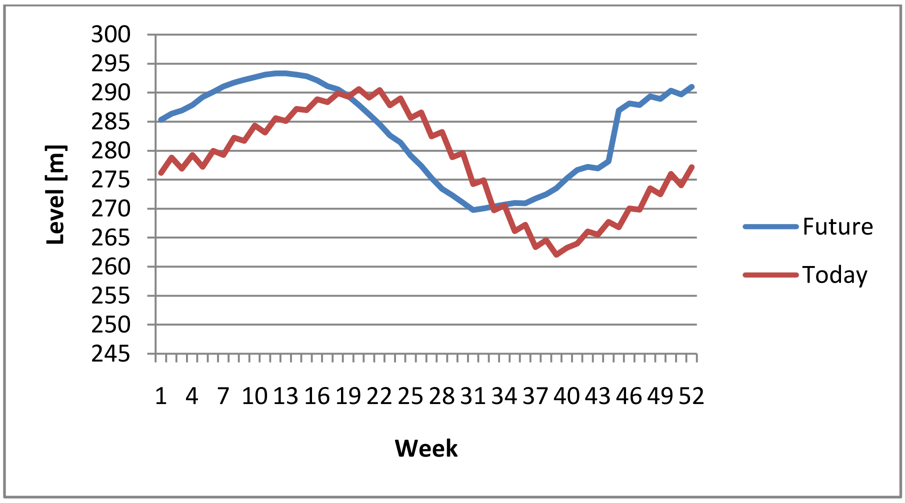

Figure 34 Reservoir level of Fierze, in present and future simulation

The blue line in figure 43 is the reservoir level for Fierze in the future scenario, while the red is simulated present. In the future scenario there is a market and other HPP upstream Fierze. Fierze reservoir can have a higher level since it is possible with more regulation in the new power plants.

Spillage in the simulations for the present and future scenario in Mm3 is given in table 29 and 30.

Future	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Fierze [Mm3]	255	15	4	3705	192	0	457	1939	94	411
Koman[Mm3]	363	13	99	5365	259	0	879	2814	230	567
Vau Dejes[Mm3]	845	160	293	6557	501	0	1391	3533	834	896
Sum flood[Mm3]	1464	189	397	15627	952	0	2728	8287	1159	1875

Table 29 Simulated flood in future

Present	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Fierze [Mm3]	362	11	0	3868	247	0	386	1938	325	400
Koman [Mm3]	639	13	65	5615	354	0	626	2814	459	579
Vau Dejes [Mm3]	1072	93	236	6821	623	0	995	3418	932	859
Sum flood [Mm3]	2074	117	301	16305	1225	0	2008	8171	1718	1839

Table 30 Simulated flood present

Difference	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Differense future – present[Mm3]	-610	71	95	-677	-273	0	720	116	-559	35

Table 31 Difference in flood, future vs present simulation

As can be seen from table 31 the difference are not very high.

11.1 The Albanian supply situation in 2020

With new transmission lines, more production capacity and a functioning market the supply situation in Albania will undergo big changes.

Through the development of a liberalized market, new market participants will take place. Traders will participate in buying and selling power at the wholesale market making economic exchange possible among the participating countries.

The opportunity to trade energy over national borders could result in more optimal dispatch of different types of generation units. For example in a wet year the countries with hydro power can produce at low costs and sell it to neighboring countries which has the lack of power. In a dry year were the water values will be high, it may be more economical for the countries with thermal power to produce and export to countries with lack of water and hydro power production. Making the electricity generation in the region thorough economical.

Another advantage from a liberalized market structure is the possibility to share reserve capacity, making the supply security in Albania and neighboring countries better.

Since Albania has the deficit of power a connection to neighboring countries with electricity surplus, the supply curve will move to the right making a new market cross with a new and lower Albanian price. This is illustrated in the figure 35 below. P2 will be the new Albanian electricity price.

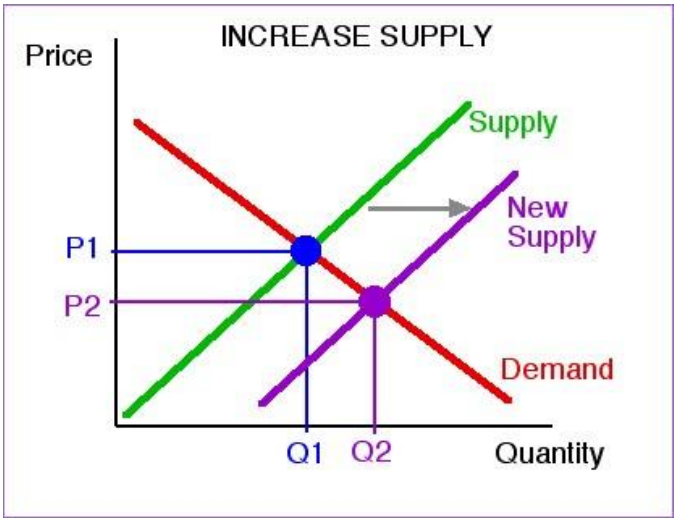

Figure 35 Shift in electricity price, when new supply enters the market.

Under more predictable market conditions, a coordinated and economic maintenance scheduling is easier to obtain, with both reduced economic risk and a more secure power delivery as results.

11.2 Discussion, part 3

In part 3, a large amount of assumptions are made, making the future scenario in many ways the best case scenario for Albania in 2020.

The first assumption is that Albania has aspired to implement the AMM. As explained in Part 2 the market is undergoing changes in the privatization process following the TMM, still there are a lot of obstacles that must be past before they are ready for the implementation of the AMM. For the AMM to function competition is needed to be effective, for this to happen a number of equal sized domestic generators or foreign suppliers must compete in the market. As of today the only company serving the country with energy is KESH gen, however some external investors are on the way to join the Albanian market. For foreign suppliers to be able to compete, interconnections with neighboring countries must be established. This is the second assumption, a cable to Italy and lines to Macedonia are built.

Further these interconnections assume flexible, reliable and efficient operators. These interconnections are also important to create a market with excess capacity, which is another criterion for getting the competition to function. Sufficient capacity is for today only possible if Albania joins the regional market.

The criteria's for Albania to be a part of the regional market are linked together. It is important that the implementation steps are taken in the right order and at the right time.

It might look impossible to accomplish all this, but as the Albanian power sector looks upon an EU membership as a national goal, EU might be able to influence the development, especially through the Athens Memo II which has made changes in Albania's electricity sector already.

The results in part 3 show the possibility to utilize the water in Drin in a more optimal way by the construction of four new HPPs. With the new plants the annual production in the Drin cascade increases 1 TWh compared with the simulation of today's situation. However from Fierze, Koman and Vau Dejes alone the production does not increase in the future scenario compared to the simulation of the present. Nor the floods are reduced. On the other hand the reservoir level at Fierze is allowed to be higher, resulting in more available capacity which could be used in times of high prices.

By comparing the historical and simulated future production in Fierze , Koman and Vau Dejes over the years in, the importance to plan the river cascade as one especially in the future is illustrated.

12 Discussion and recommendation for further work

The main purpose of this study was to optimize the use of the hydro resources in Albania. The simulations with the EOPS model show the possibility to utilize the water in a better way both under the present situation and in the future. However it is important to remember that to produce as optimal as the model suggests is not possible in reality. The real inflow is hard to predict and same for the price level and variations in the future. Important aspects as maintenance are also not included in the model.

Today maintenance schedules do not exist within KESH gen, a power plant is run until a breakdown occurs. A settled strategy for maintenance could lead to an increasing production in Albania. A maintenance strategy is important for the security in the supply situation as well. To straighten out a maintenance strategy is an interesting task for further work, with a high improvement potential.

In part 2, lack of data on detailed level made it impossible to look closely at the pattern of production and the management of the reservoir on short term basis. Looking at these issues on hourly level for each turbine could show if KESH gen run its plants optimaly. To make simulations at such a detailed level short term models like SHOP could be used.

In part 3 more scenarios could have been worked out. There are several ways in which the market could develop, especially if some obstacles towards the regional market fail. As mentioned building three HPPs in upper Drin is a proposal from Statkraft, it is possibility that the final decision will be one power plant with a huge reservoir. This would affect the three downstream power plants in a different way.

If participating in the REM is accomplished Albania may become a swing producer at the Balkan since they have a large amount of hydro power. This potential could have been interesting to analyze as new plants are developed which may be suitable to run as effect power plants.

13 Conclusion

The electricity market in Albania is today undergoing changes in the privatization process following the Transitory Market Model (TMM). The initial structure of the TMM intended to be a transition phase that provides flexibility for the Albanian market to evolve toward full compliance with the EU directives and the Regional Electricity Market (REM). Albania follows the TMM until the full implementation of the Albanian Market Model (AMM).

Under the process towards a liberalized market the optimizing problem regarding the production planning will change. Today the main task is cost minimization given an expected demand. In a free market it will be profit maximizing given a price forecast.

Albania suffers from a deficit of electric power, and it is today a net importer. The demand is expected to grow up to 10 TWh in 2020. Even with new power plants under construction it is important that the production company utilizes the water as optimal as possible to be able to cover the demand and to compete economical in a future regional market.

The lack of power has a huge rationing cost for the Albanian society today, as it prevent industry to function and grow. The same is likely to happen in the future.

In part 2 improvement potential in production planning was discovered. In an average year the production in Drin is through simulation increased with 1.3 TWh. Fierze power plant has the highest potential with 25%, followed by Vau Dejes with 22% and Koman with 18% looking at the years 1995-2005. Even though this is optimal production which is not possible to achieve taking maintenance, uncertain inflow and prices into consideration the potential is definitely there.

In part 3 new power plants were implemented into the EOPS model. With new plants in the Drin and a functioning market it is possible to achieve 1 TWh more production during an average year compared with the simulation for the present situation in Albania. The production curves over the years show the importance of considering the whole stream as one while making the production plans. More plants and reservoirs in upper Drin allows Fierze reservoir to have a higher level.

The importance of good planning will continue to grow as the Albanian power market is liberalized.

If the implementation of the market, new power plants and transmission lines are accomplished, the supply situation in Albania will improve substantially through more secure power delivery. However a participation in a regional market forces the production company to plan each day like the participants in the Nordic market, both in long and short term, if they are going to be able to exploit the opportunities, compete financially and develop their country.

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Appedix A

Map of Albania

Appendix B

Tariffs from ERE for tariff customers

Retail electricity tariffs for tariff customers approved by the Decision 21, dated 021408 of ERE for the period March 1, 2008 - February 28, 2009

Voltage Level	Customer Categories	Approved tariffs (lek/kWh)	Tariffs for reactive power leke/kWAr	Peak energy prices (lek/kWh)
HIGH VOLTAGE	HV transmission customers with assets owned by them			
	Industry	5.20	0.78	9.00
	Commerce & Services			
	Agriculture			
	Others			
	Customers supplied at distribution 110 kV substations			
	Industry	7.00	1.05	9.64
	Commerce & Services	7.00	1.05	9.64
	Agriculture	7.00	1.05	9.64
	Others	7.00	1.05	9.64
MEDIUM VOLTAGE	Customers supplied at 35 kV			
	Industry	7.50	1.13	10.00
	Commerce & Services	7.50	1.13	10.00
	Agriculture	7.50	1.13	10.00
	Others	7.50	1.13	10.00
	Customers supplied at 20/10/6 kV			
	Industry	8.00	1.20	11.00
	Commerce & Services	8.50	1.20	11.00
	Wheat industry& bakeries	7.00	1.05	11.00
	Agriculture	8.00	1.20	11.00
	Others	8.00	1.20	11.00
	Budgetary	10.00	1.41	11.00
LOW VOLTAGE	Customers supplied at LV			
	Industry	9.50		
	Commerce & Services	10.00		
	Wheat industry& bakeries	7.50		
	Agriculture	9.50		
	Others	10.00		
	Budgetary	12.00		
	Average tariff for non-household customer	8.73		
	Average tariff for household customers	8.23		
	First Tier up to 300 kWh	7.00		
	Second Tier above 300 kWh	12.00		
	Fixed service tariff for customers with no energy consumption (lek/month)	200		
	Tariff for electricity consumption in common spaces (condominium) (lek/kWh)	7.0		

Note: The peak tariff will be applied for the energy consumption during the following time p

For period from 1 November to 31 March
For period from 1 April to 31 October

Appendix C

Technical specifications to the EOPS model

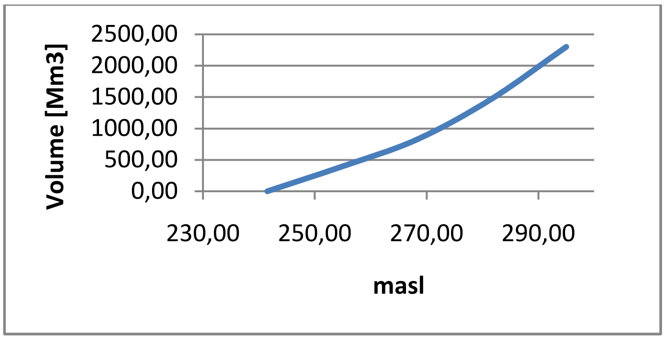
Fierze

Reservoir volume: 2300 Mm3

Energy equivalent: 0,31 KWh/m3

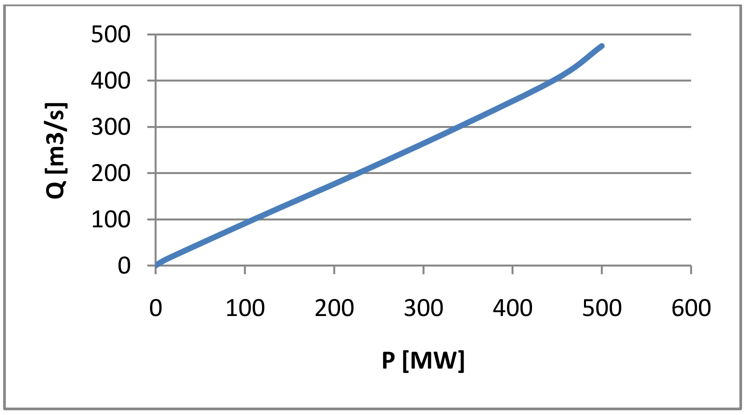
Reservoir curve

	moh	Volume(live)
LRV	241.50	0.00
	254.88	394.50
	268.25	822.90
	281.63	1470.00
HRV	295.00	2300.00



PQ curve

Q [m3/s]	P [MW]
0	0
14.80	13.3
102	112.5
198	225
298	337.5
405	450
475	500



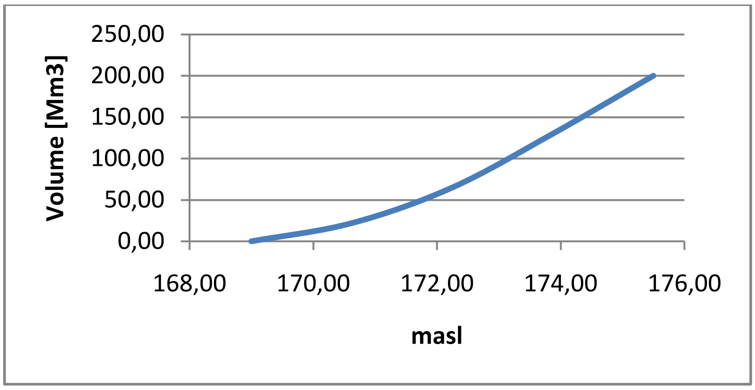
Koman

Reservoir volume: 200 Mm3

Energy equivalent: 0,24 KWh/m3

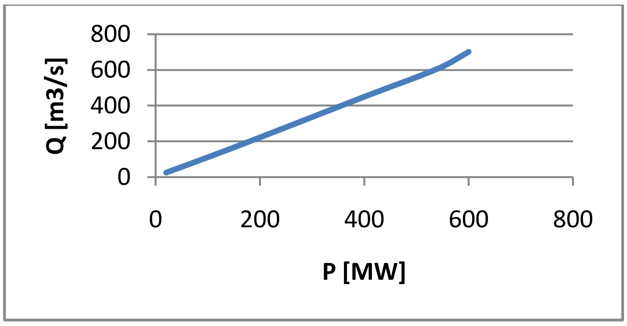
Reservoir curve:

	moh	Volume(live)
LRV	169.00	0.00
	170.63	22.00
	172.25	65.00
	173.88	130.00
HRV	175.50	200.00



PQ curve

Q [m3/s]	P [MW]
26	20
150	135.00
302	270
455	405.00
605	540
700[4]	600.00



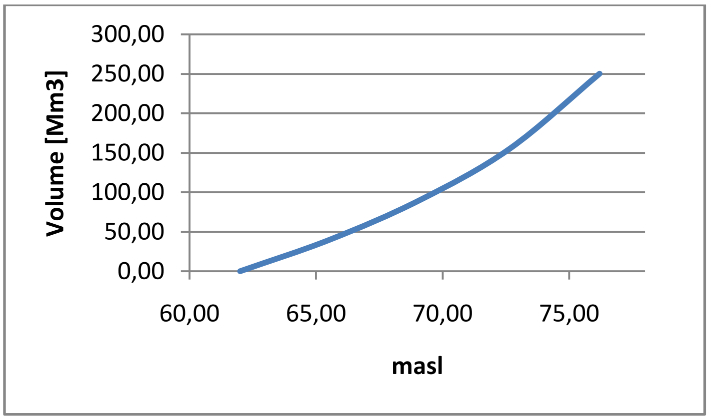
Vau Dejes

Reservoir volume: 250 Mm3

Energy equivalent: 0,12 KWh/m3

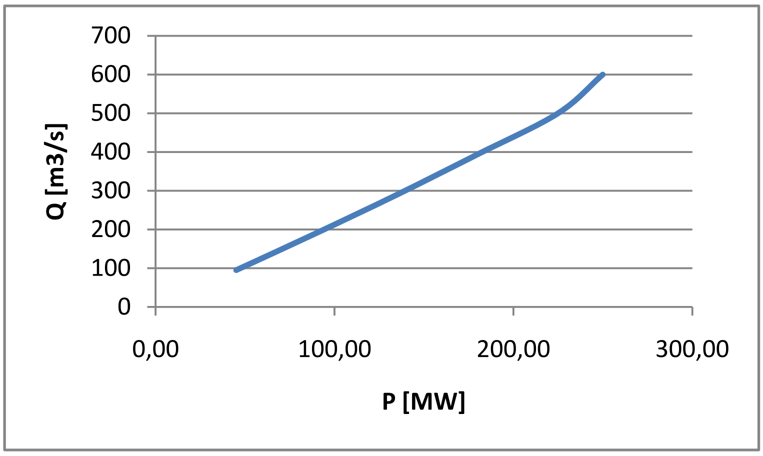
Reservoir curve:

	moh	Volume(live)
LRV	62.00	0.00
	65.55	40.00
	69.10	90.00
	72.65	155.00
HRV	76.20	250.00



PQ curve

Q [m3/s]	P [MW]
35	15.00
95	45.00
191	90.00
290	135.00
394	180.00
500	225.00
600[5]	250.00



[1] and [2] : In the PQ curve for Vau Dejes and Koman the Qmax is set higher than in the technical specifications given directly from KESH. This is to get a reliable efficiency factor. With the Q max given (Koman 600m3/s and Vau Dejes 500 m3/s) the efficiency factor will be over 1 which is not possible.

Appendix D

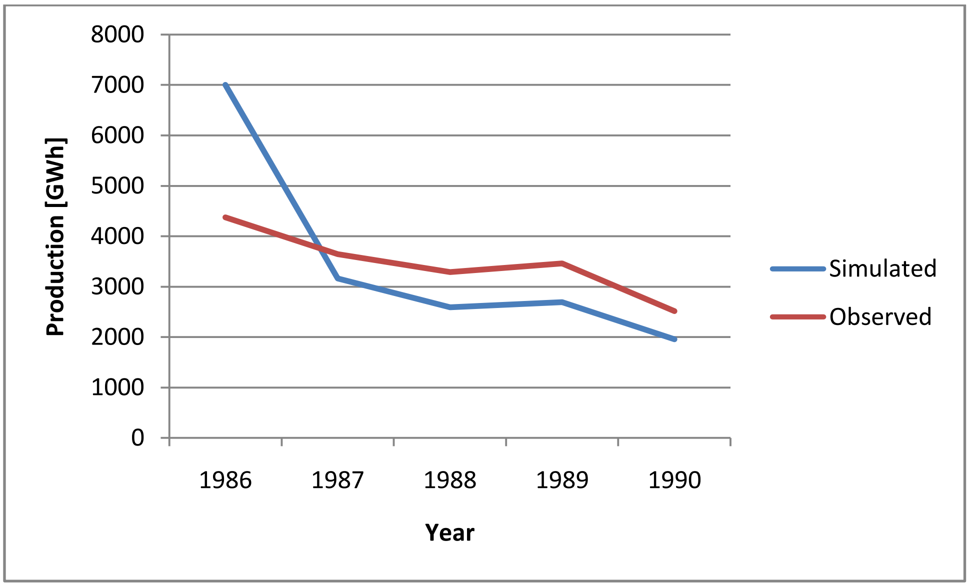
Simulation with hydrology series 3554-R Black Drin

Simulation

	Vau dejes	Fierze	Koman	Drin
1986	1500.2	2362.3	3140.3	7002.8
1987	752.7	958.5	1450	3161.2
1988	603.5	802.7	1183.8	2590
1989	650.3	809.4	1232.7	2692.4
1990	479.4	570.8	904.4	1954.6

Observed

	Vau Dejes	Fierze	Koman	Drin
1986	1095.2	1854.9	1424.6	4 374.7
1987	888.8	996.1	1758.7	3 643.6
1988	804.8	906.9	1575.4	3 287.1
1989	815.3	1044.5	1601.2	3 461.0
1990	621.5	638.5	1251.4	2 511.4



Diff.
-2 628.1
482.4
697.1
768.6
556.8

The huge difference in 1986 can be explained by this being the first operation year for all the three power plants in Drin. It is normal that during the first year of operation there will be a lot of stops.

The next three years are difficult to explain, it could be that the reservoirs in Drin were full entering 1987 and had a lot of water that the model didn’t have. But still this shouldn’t be enough to produce the high historical amount in three relative dry years. The hydrology series could also be wrong, giving the model to little water in this period. Another reason could be that the observed production is not correct, an assumption that is impossible to verify.

To get the simulated production up to the observed level the volume for Fierze must be lifted up to 9000 Mm3/year. There is no more production to get from the technical data.

Three years are not enough to draw a good explanation and conclusion, other hydrological series within the same area where therefore considered.

Appendix E

Simulation input, present market.

Contractual obligation

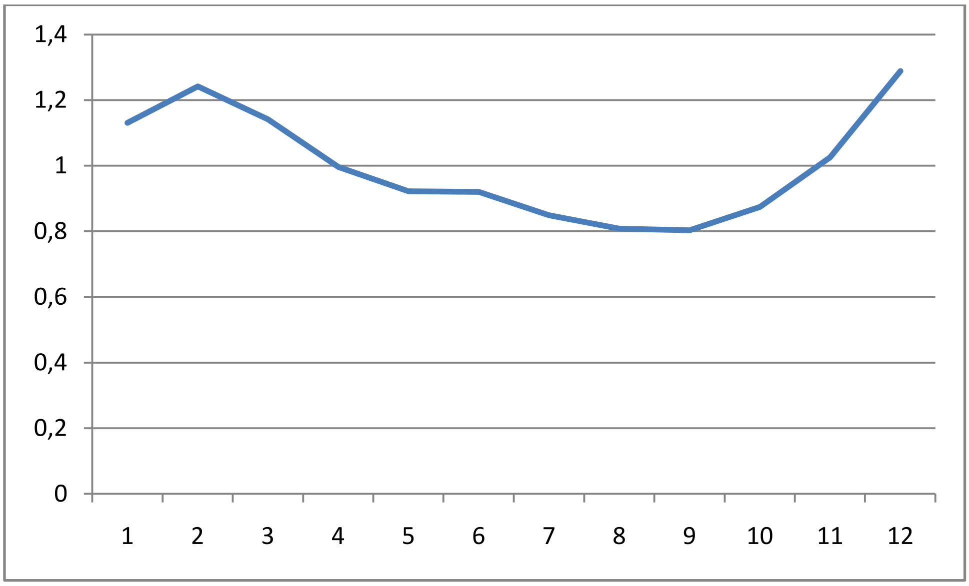
The firm demand is set to 6300 GWh per year, this is the level from 2008.

The profile is calculated from the demand each month in 2007.

Month	Demand	Relative value
1	743	1.130324544
2	816	1.24137931
3	750	1.140973631
4	655	0.996450304
5	606	0.921906694
6	605	0.920385396
7	558	0.848884381
8	531	0.807809331
9	528	0.803245436
10	575	0.87474645
11	674	1.02535497
12	847	1.288539554
	657.3333333	average monthly demand

First the average monthly demand is calculated, than each month is divided by the average demand to get a relative value.

The profile is shown in the graph below



Import

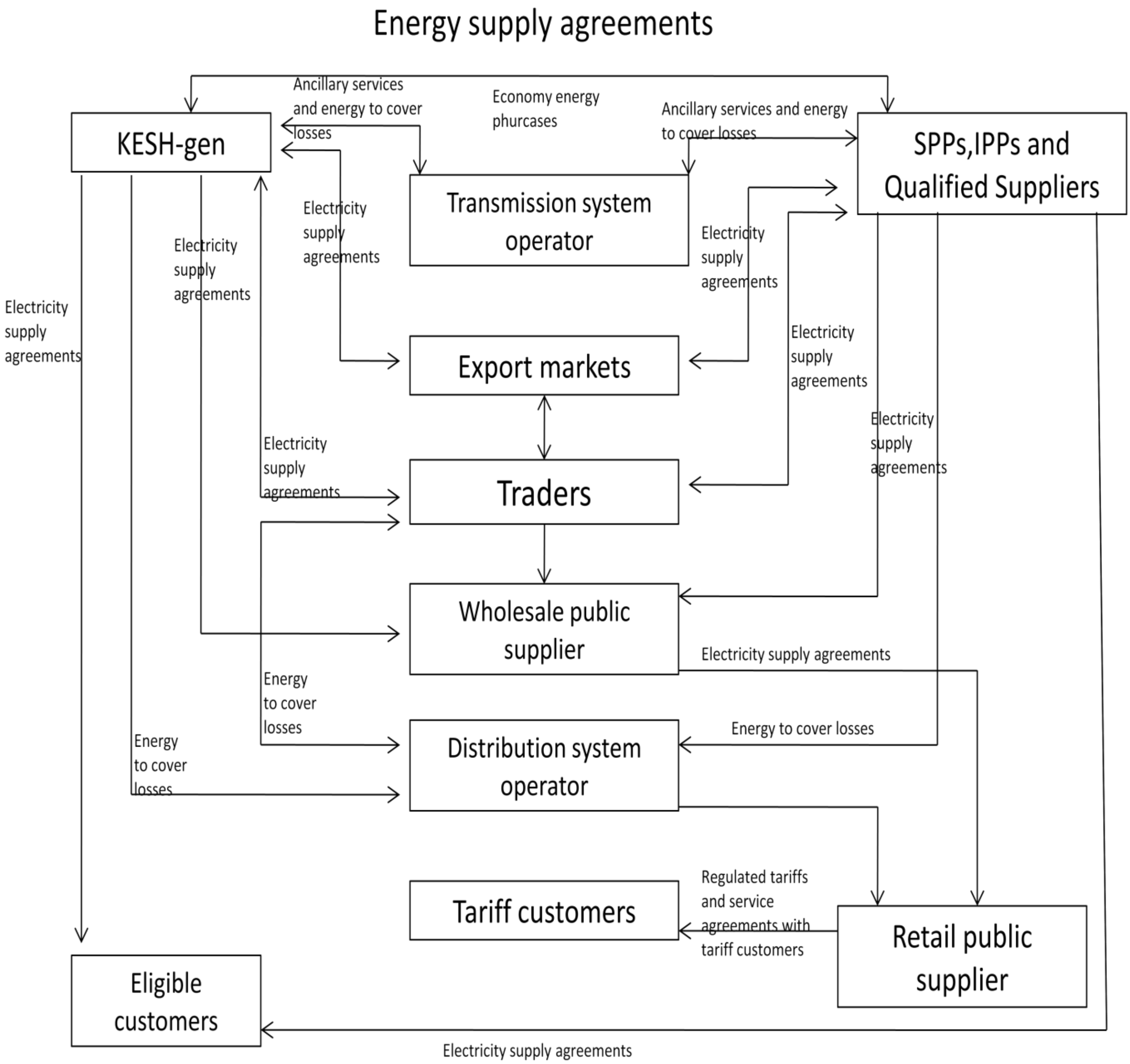
The highest amount imported to Albania during one month is 285 GWh (in March 2008), this is therefore set as the highest amount the grid can handle.

Number of hours during the night is set to 5 on ordinary days and 7 on weekends. Approximately 40 hours in night per week. The remaining hour's, 128, are day hours.

The import amount per month is divided with 720 hours per month to get maximum import volume per hour. This factor, 0.395833, is multiplied with the numbers for night and day hours to get the volume.

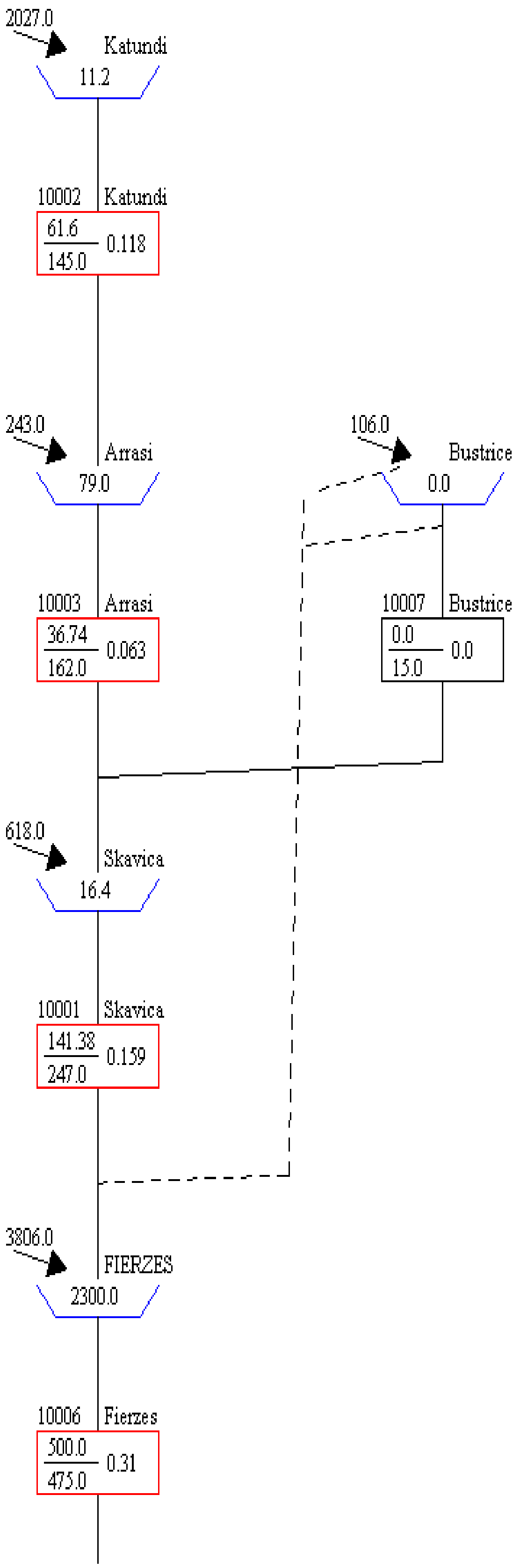
Appendix F

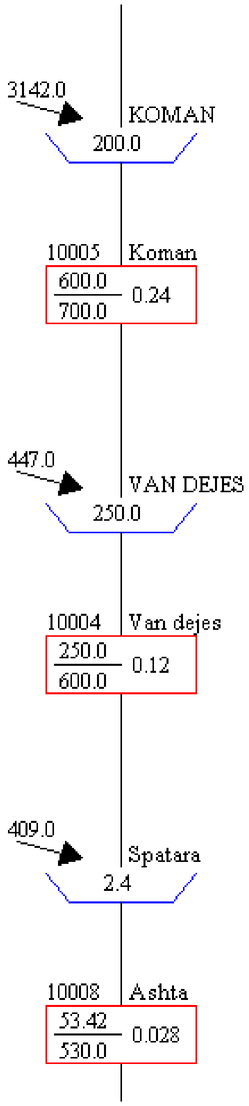
Energy supply agreements



Appendix G

River system scheme future scenario




3142.0
KOMAN
200.0
10005
Koman
600.0
700.0
0.24
447.0
VAN DEJES
250.0
10004
Van dejes
250.0
600.0
0.12
409.0
Spatara
2.4
10008
Ashta
53.42
530.0
0.028